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ABSTRACT

Researchers, coaches, and players of racquet sports were brought together for this symposium on four racquet sports. Although most of the papers presented at the symposium were written by Americans, one of the speakers was from Canada, and another was from Australia. The sports represented were badminton, racquetball, tennis, and squash. In Part I, four papers on sports medicine, biomechanics, and exercise physiology are presented. Among the topics are tennis elbow in badminton, cardiovascular endurance training, and a force platform study of power strokes. The six papers in Part II address skill acquisition and teaching strategies, such as the teaching behaviors of university tennis instructors and successful methods of teaching serves and stroke techniques. Sports psychology in tennis was the subject of the three papers in Part III, and Part IV consists of a paper on contemporary tennis research and its application by the practitioner. Each paper is preceded by an abstract, and most have a brief list of references. The final article is a synthesis of research and its role in the teaching and coaching of racquet sports. (FG)

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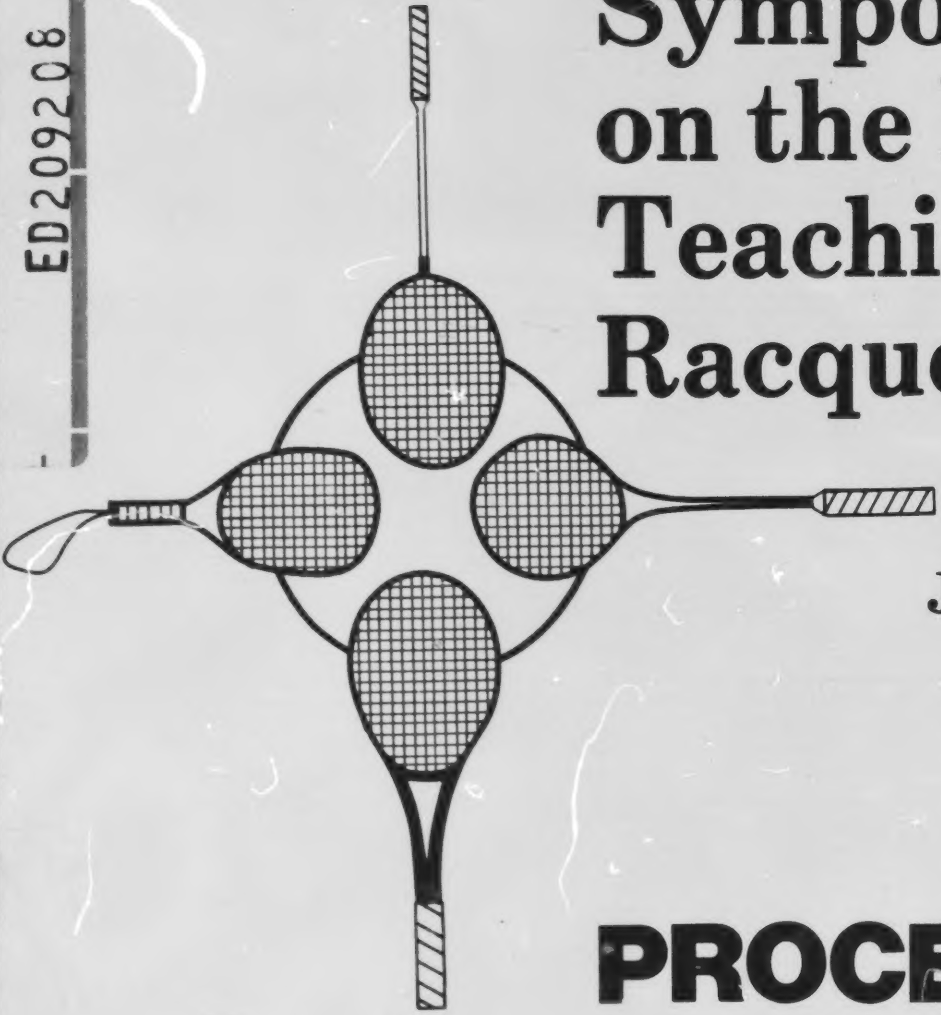
ED209208

# International Symposium on the Effective Teaching of Racquet Sports



June 11-14, 1980

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Jack L. Groppel
and
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# ACKNOWLEDGMENTS

In order to efficiently and effectively organize and conduct a symposium of the nature and magnitude of this "International Symposium on the Effective Teaching of the Racquet Sports," many dedicated individuals must give of their time and expertise. Special thanks should, first of all, go to AMF Head Racquet Sports and AMF Head Sportswear for a generous grant to defray the cost of promotion and administration. Without this funding, as well as the support of the Coto de Caza Sports Research Center, the goals of this symposium would not have been realized. The following individuals, each of whom gave advice and assistance, also deserve special recognition: Kevin Campbell, Nancy Casey, Charles J. Dillman, Peter Hancock, Peter McGinnis, Kathy McGreal, Peter Milburn, E. Keith Milner, L. Russell Morris, Karl Newell, Linda Pecore, Fontaine Piper, Douglas Stewart, Terry Ward, and Barbara Young. Our appreciation is also extended to the staff of the Office of Conferences and Institutes who assisted in the administration of this symposium. Terri Bodeker and Donna Flammang deserve our sincere thanks for patiently typing various drafts of the manuscripts, which were skillfully copyedited by Theresa L. Sears.

Jack L. Groppel, Ph.D.
Ronald G. Sears
Symposium Coordinators
December 1980

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# OPENING REMARKS AND PREFACE

by

Vic Braden
Coto de Caza Sports Research Center
Trabuco Canyon, CA

Let me tell you how happy I am that you have come to this symposium. We run the U.S. Tennis Academy for tennis coaches, and we have about 100 coaches for each session. Now, we will always get 30 people who come because they are genuinely concerned about the profession, and we get 70 who come because they want to make $40 per hour and I ask them "Why?" Well, what I am basically concerned about is the professional nature of all sports. For those of you who are here for badminton or racquetball, the same problems exist. What we are trying to do is to make the teaching/coaching of tennis a profession. The teaching of racquet sports has never had good support in terms of research. When you want answers, you either can't get them or it is very difficult. Then you say, "Well, I think I will do it myself." So you go off and try to do it on your own. What the University of Illinois has done is to bring together individuals who are dedicated to studying the racquet sports to give you, the conference participant, the best education possible. Actually, to be honest about it, there should be 5,000 to 10,000 people attending this conference. In fact, I'll guarantee you that you're going to get information here from the researchers that other people in the field are not aware of. You are going to get ideas for your own research, and that is what everyone hopes will come out of this. You should be excited enough to start generating some of your own projects and then come back to contribute next year (and hopefully make $40/hour!). I learned an awful at this conference last year, and I will try to highlight those points in my clinic. At Coto de Caza, we do a lot of research and we are surrounded by theoretical physicists, biomechanists, exercise physiologists, and a mathematician.

I hope you will ask a million and one questions. Some people feel intimidated, and that bothers me a little bit because the problem we face is to try to get researchers to speak in language that practitioners can really understand. The converse is also true: the coach needs to talk in terms the scientists can understand, which is difficult sometimes because a researcher thinks in terms of angular displacement, velocity, etc. You, the practitioners, want to know when and why, but you don't need to know all the terms that scientists use; the latter can be done at a more detailed conference. So, I am making a personal plea to you: when a researcher or coach is going a little bit too fast, let's "nail" the person--let's say, "Hey, can you bring this back down to where I can understand it." I think the researcher has the right to ask the instructor to formulate the question in such a manner that they can intelligently get the decisions, because some of the questions that I have gotten are very, very generalized. I feel that you can get 25-50 thousand dollars worth of research out of this conference if you'll use it and not be intimidated by anybody. As for me, I love to see how many people can say to me, "I do it this way." If it works, great! I don't care if they play by sticking the racket under their armpits, as long as they hit the ball well. If they are good that way, they will be more in demand than anybody in the history of the game. So I'm not here, and doubt if anybody else is here, to say, "You have to do it in a particular manner." But it is very important for you to understand what the physical laws are so that you are not out there making a fool of yourself with someone who does know the laws. The racquet sports have not been well researched, but that also means that they provide a tremendous opportunity for all of us to get out and do some research. We hope that everyone at this conference will begin to think about setting up a plan, a system, for teaching.

What do you use to evaluate your teaching system? The basic theme is: "I have a student do it this way because I said so and I know best." Well, this is why I am pleading with you. I am so delighted that these people at the University of Illinois put together this conference because more and more data are always becoming available. Moreover, the people who don't take a keen interest in finding out what is going on are going to be exposed as people who don't care and who have been robbing their students. Now we also know, as we are teaching, that one of the biggest problems we face is: "I don't do it that way and I am not about to change." Nobody says that you have to do something in a particular manner and you don't have to change if you have the proper rationale for teaching your methods. But you owe it to your students, if you are taking their money, to provide the rationale for your system. If you already have a system, you are way ahead of most people. But we are hoping that if it is not a good system you'll use this conference to help revise or update, or grade or evaluate your techniques.

Nobody has to be defensive. No one sitting in this room has all the answers. But I would advise you to at least investigate the system, to say to your students, "I really have worked hard to stay up on research. I will also analyze the research in a very critical fashion, and if all the statistical analyses are accurate, then look at the information that I get." If there are indications for a change in your teaching style, then change. Don't be worried about going back and having to say to the student, "Maybe I was wrong about this." Think about all the people in electronics, mathematics, physics, and geology right now with new discoveries that are making people in various universities eat crow. Professors have been standing in front of their classes for 20 years saying that something is true and now they find out it is no longer true. And the only defense they have is that they are open to new ways. This is basically what we are suggesting; at least, is what I am personally suggesting. I don't think that anyone you teach in the school system or privately would ever complain because they are getting the very best. If you use this conference properly, it could serve as a great anxiety-reduction mechanism. When you start to point out new things, and find out where you can get the research, and how you might even start something, it is exhilarating. You'll find that many things you are just being defensive about really are right. You can go back and relax a little bit and not worry about somebody coming to your club and telling people something else. You may even sleep a little bit better.

Once again, to the researcher and to all of you, try, try, try again to be clear with the language so that it is universal and so that you each understand what the other is saying. I would suggest that you go back this evening and ask yourself questions. First, all of you have to ask the question "What did I learn?" If you answer that question in a confident manner and provide the rationale for the answer, it is going to be worth $25,000 to you. If you are afraid to ask questions or if you are intimidated and quiet, then I think you are doing yourself and your students a real disservice. Again, physical laws dictate what happens to a ball, a bird, anything, when it hits the racquet and you've got to honor those laws. Your students cannot violate them if they are to be successful. To produce a certain number of revolutions on a ball, a certain speed, hit it at a certain axis, the racquet can't meet the ball at two difference places.

There are some coaches who don't know an awful lot about physics, but who have produced a lot of real champions! It would really be nice if we could have both, and I think we can. As a matter of fact, we recently had some

Russian scientists at Coto de Caza who were scheduled for a two-day conference. It ended in 3 hours! They asked me why we had developed so many champions and they hadn't. Now, they take a lot of youngsters out of school when they are 8 years old, and they conduct all kinds of dexterity and reflex tests. They do all kinds of things, but they don't produce champions. The reason they don't is a lack of communication. But I didn't say it right. I told them "It is because of your political system". That didn't set too well, so they left right after lunch. The reason I said it is that I have seen all the great champions in my life--I have run pro tennis for Jack Kramer and I ran the women's tour--and all of these great tennis champions have been independent thinkers. Now, the Russian players are very intelligent, but they are dependent thinkers; every time they play, they turn to the coach for an acceptance or a rejection. No great champion has ever worked that way. What a good coach does is to encourage his players to think in an independent manner. And my pet peeve (and I am going to step on some toes) is that I don't like it when a coach or an instructor says "Tomorrow we play!" We don't play anyone. We don't run out there and intercept and hit the overhead smash. The students play. As a professional, your goal is to get good information and to assimilate that information. Help the youngsters think in an independent fashion and be as successful as possible up to their own potential. When you have done that, it is great.

We know some youngsters are great in spite of the coach! What coaches often say they are teaching and what the student is really doing, are very, very different things. But, the youngsters are so smart they imitate a particular player and pretend to be listening to the instructor. That is smart. That is a champion. The student learns how to solve problems. What

I am saying is don't show me all the champions; show me those 15 people who buy ice cream cones and put them onto their foreheads. How do you teach them?

As for me and my particular system, I want to teach people to play better, much sooner, in a more effective manner, and to learn how to have more fun. Basically, those are my objectives. So, when I go to evaluate my own teaching system, I see if I have done those things. You can only evaluate your program in terms of its original objectives--or at least revised objectives.

I would hope that while you are here and participating in this conference, you are helping the other conferees go in that direction. The conference is going to meet some of your needs, but we want you to be flexible. In summary, you can review your old system or you can complain and you can say "I've got my own system" or "I do it this way." The one wonderful thing about our profession is that of all the people you teach, someday you will be standing around the fence and somebody is going to say to one of your students, "I've heard all those stories you've been telling people about how great a player you are, and what a tremendous instructor you have." You will be right out there on display. That is why I think we should all be a little bit humble and a little bit careful. We don't know it all, but we are sure getting to know a lot more.

# SPORTS MEDICINE,
# BIOMECHANICS,
# AND
# EXERCISE PHYSIOLOGY

# TENNIS ELBOW AMONG BADMINTON PLAYERS

by

Larry D. Hensley
University of Northern Iowa
Cedar Falls, IA

Donald C. Paup
George Washington University
Washington, DC

## Abstract

During the past decade, lateral humeral epicondylitis ("tennis elbow") has received considerable attention from physicians, athletic trainers, and athletes. Although substantial evidence has been presented regarding the symptons, etiology, treatment, and (more recently) the high incidence of tennis elbow among tennis players, only limited epidemiological information is available regarding its incidence among other racquet sports participants. The purpose of this study is to determine the incidence and type of injuries--particularly tennis elbow--among badminton players. Questionnaires were completed by 231 participants in sanctioned badminton tournaments in the United States and Canada during the 1976-77 season. It was found that most badminton-related injuries (70%) were to the lower extremities and that only about 7.4 % of the players experienced elbow pain at some time during their playing careers. A possible explanation is given for the low incidence of "tennis elbow" among badminton players.

Lateral humeral epicondylitis, commonly referred to as "tennis elbow," has received considerable attention from physicians, athletic trainers, and athletes during the past decade. The dramatic increase in tennis participation in recent years has precipitated an increased interest in elbow injury among tennis players. It has been reported that anywhere from 30% to 50% of all tennis players will experience elbow pain at some time during their playing careers. Although substantial evidence has been presented regarding the symptoms, etiology, treatment, and (more recently) the incidence of tennis elbow among tennis players, only limited epidemiological information is available regarding the incidence of tennis elbow among athletes participating in the other racquet sports. The purpose of this study is to determine the incidence and type of injuries associated with participation in competitive badminton. Although badminton is a noncontact sport, the game requires great stamina, jumps, lunges, quick changes of direction, and rapid arm movements in order to stroke the shuttlecock from a variety of postural positions. Thus, the physical demands of a competitive game of badminton suggest that injuries to the limbs may be a prevalent ailment. Of particular interest to this investigation was the frequency of elbow pain among badminton players.

Questionnaires were completed by 231 participants in sanctioned badminton tournaments in the United States and Canada during the 1976-77 season. The questionnaire was designed to elicit specific information concerning the players' sex, age, height, weight, number of years playing badminton, practice schedule, and type of racquet, as well as the type, location, cause, frequency, and severity of injuries associated with badminton play. The questionnaires were personally administered by the investigators, who screened the records for completeness and appropriateness in method of recording the responses.

The results are only a sampling of the number and type of injuries incurred and are susceptible to the customary limitations encountered when nontrained individuals complete injury report forms. The participants ranged in age from 11 to 71 years, with men averaging 33 years and women averaging 27 years. The typical man surveyed had played tournament badminton for 11 years, while the typical woman had 8 years of tournament experience. Of the 231 respondents of the survey, 82% indicated that they had suffered from at least one injury while playing badminton. The injuries most frequently reported among both men and women were soft tissue injuries to the limbs, particularly the legs, which accounted for about 70% of all injuries reported (Table 1). The incidence of severe injuries, however, was strikingly low: less than one in five reported injuries was considered major enough to require treatment by a physician, although this proportion was higher for eye injuries.

Table 1

Location of Injuries

| Body Part | % of Total Injuries |
|---|---|
| Ankle/Foot | 43 |
| Knee | 9 |
| Leg | 17 |
| Shoulder | 2 |
| Elbow | 9 |
| Arm | 4 |
| Hand/Wrist | 6 |
| Neck | 1 |
| Eye | 4 |
| Other | 5 |

Of the 231 badminton players surveyed, 20 (15 men and 5 women) reported experiencing elbow pain, predominantly tennis elbow, at some time during their playing careers. Three of these cases, however, were recurrences of nonbadminton-induced injuries. The results of this study suggest that about 7.4% of the participants first experienced tennis elbow while playing badminton. Although comparisons between epidemiological data from difference sports should be viewed cautiously, the percentage of badminton players with a history of tennis elbow is notably lower than similar figures reported among tennis players (Table 2).

Table 2

Players Reporting Tennis Elbow

| Sport | History of Elbow Pain (%) |
|---|---|
| Tennis | 31 |
| Badminton | 7.4 |
| Squash | 7.6 |
| Racquetball | --- |

The fact that elbow pain among badminton players is substantially less than among tennis players may be partially attributed to (1) differences in the weight of the respective racquets and the objects struck, and (2) differences in the stroking patterns in the two sports. The force generated for the swing in badminton is more dependent on forearm rotation and wrist flexion (forearm) musculature), compared with the upperarm dominance in tennis.

A profile of those badminton players with elbow pain compared to those without pain is strikingly similar to that reported by Priest, Braden and Gerberich (1980a) for tennis players (see Table 3). It is also interesting to note that for players who reported a history of elbow pain, the frequency of play and tournament participation was higher. While the ability level at the time of injury is not known, a trend toward greater ability was seen in those players with a history of elbow pain. In fact, not a single player who had elbow pain was classified as a beginning-level player, whereas approximately 10% of those players without elbow pain classified themselves as beginners.

Table 3

Comparisons of Players Without Elbow Pain

| | Tennis | | Badminton | |
|---|---|---|---|---|
| | Pain | No Pain | Pain | No Pain |
| Age | 42 | 36 | 37 | 31 |
| Weight - Men | 175 | 170 | 168 | 162 |
| - Women | 126 | 122 | 130 | 123 |
| Years of Play - Men | 9.9 | 6.4 | 14.2 | 12.1 |
| - Women | 7.6 | 4.2 | | |

Players were asked to identify the type of badminton racquet used. Although it may be erroneous to presume that the same racquet was used at the time of injury, it was interesting to note that a Carlton racquet was used by 70% of those players reporting elbow pain, while only 48% of those without pain reported using this particular racquet.

The majority (55%) of players reporting tennis elbow received medical attention for the injury, but none required surgery. Although the success of their treatment was not ascertained, 30% indicated that they currently used an elbow band when playing badminton. Also, three players thought that participation in badminton was serving a rehabilitative function.

Our findings parallel those reported by Priest et al. (1980a, 1980b) for tennis players (see also Hensley and Paup 1979). Age, weight, years of play, frequency of play, and ability level are all significantly different between groups of players with and without elbow pain. As has been suggested, the harmful effects of playing tennis, or badminton, may be cumulative and many factors may interact before elbow pain occurs. However, from an orthopedic point of view, badminton participation is a relatively safe form of exercise with an apparent lower incidence of elbow pain than is associated with tennis play.

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# RELATIONSHIP BETWEEN BALL VELOCITY AND SELECTED BIOMECHANICAL FACTORS FOR MALE AND FEMALE PLAYERS IN THE BACKHAND KILL IN RACQUETBALL*

by

James W. Kent
David A. Barlow
Robert Craig
Biomechanics Laboratory
Department of Physical Education
University of Delaware
Newark, DE

## Abstract

The purpose of this study is to identify mechanical aspects that enhance performance of the backhand kill shot of high-level male (4 'A') and female (3 'A') players. High-speed cinematographic techniques (100 fps.) are used to investigate performance of the backhand kill in determining relationships between ball velocities and selected biomechanical factors. Computerized analysis of film data enables the determination of linear displacements, velocities and centers of gravity. Descriptive statistics are used to present relationships among male and female players. Although mirror imagery of backhand/forehand strokes occurred from greatest height of racquet head in backswing to ball contact, results from a previous study show that no other similarities of mechanical technique are found to support the thesis of mirror imagery of total forehand and backhand stroke technique. Implications of the study are presented.

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* This study was supported in part by a Faculty Research Grant from the University of Delaware and from the PLATO Project at the University of Delaware. The authors are indebted to the Branmar Racquetball Club of Wilmington, Delaware, Debbie Mayhart, comanager, David MacKelcan, comanager/professional, and to the players who participated in this study.

Successful play in racquetball is very often determined by the ability of the player to execute a wide variety of shots. The learning of one particular shot, the backhand kill, is often approached by the beginner with great trepidation. Lack of confidence and a history of non-success with the backhand shot in other racquet sports very often leaves the beginner with the attitude that racquetball won't be much fun because his game is wanting for a backhand.

The teaching methodology developed for the presentation of the backhand has been inititated through kinesthesis and observation by high-level players. The technique descriptions in the performance of this shot are reported in various technique books and are the result of personal experience, self-analysis, observations and discussions with high-level performers. The purpose of this study is to examine and quantify the biomechanical characteristics exhibited by high-level female and male players while hitting the backhand kill shot and to assess the appropriateness of various teaching cues that are found in the teaching of racquetball.

## METHODOLOGY

The racquetball players (n=7) were filmed through a plate glass wall in the natural environment of a racquetball court. The filming was completed by using an electrically driven 16mm. Locam camera (164-4DC) operating at 120 f/s. Two banks of colortran (mini-brute 9) lights, set at $45^o$ angles to the subjects, were used to provide sufficient lighting. A Hercules tripod supported the camera 40 ft. directly opposite and perpendicular to the center of the hitting zone in the racquetball court. The complete backhand kill stroke was filmed, from ball drop to completed follow-through of the stroke. The players were approximately 28 ft. from the front wall when each trial was filmed. Each subject was filmed for three successful trials of the backhand kill shot.

The quantified precision analysis of high-speed film was facilitated by using a Vanguard 16mm. motion projection head (M-16C) in conjunction with a Summagraphics Bitpad interfaced with a PLATO programmable terminal, thereby permitting rapid and precise determination of "X" and "Y" coordinates for segmental points of the racquet, ball and body. This assisted in the application of the segmentation method (see Miller and Nelson 1973) necessary for the determination of each player's center of gravity (see Barlow, Markham, and Richards 1979), as well as height of the ball at contact with the racquet, ball velocities, range of motion of the racquet from the top of the backswing to contact with the ball, length of stride in relation to standing height, distance of the vertical line of the center of the shoulder to the position of the ball at point of racquet contact, and the distance from the ball to the big toe of the front foot.

The "Film Motion Analysis" computer program of the University of Delaware PLATO system (Barlow et al. 1979) was used to provide rapid determination of centers of gravity, along with linear and angular measures of displacement. The participants in this study were all judged to be "open"-level competitors in racquetball. Four males and three females were analyzed for this study; their physical characteristics are summarized in Table 1.

TABLE 1

Physical Characteristics of Subjects

| | Age $\bar{x}$ | Age s.d. | Height $\bar{x}$ (in.) | Height s.d. | Weight $\bar{x}$ (lbs.) | Weight s.d. |
|---|---|---|---|---|---|---|
| Female (n=3) | 23.3 | 3.79 | 65.0 | 1.00 | 128.67 | 7.10 |
| Male (n=4) | 28.5 | 3.87 | 71.0 | 3.16 | 169.25 | 14.10 |

## RESULTS

Comparison of the mean values of the height of the ball from the floor at the moment of contact with the racquet (see Table 2) indicates that the female players were consistent with the male players. The height of the ball from the floor for the male players during the backhand stroke was 26.8% greater than the height of the ball for the forehand kill, as reported in a previous study (Kent and Barlow 1979). The range of the distance traveled by the racquet from the start of the foward swing to the point of ball contact was very similar for the two groups of players. The mean value of the male players is somewhat greater than the female players but that is the result of the extreme value recorded by one subject. With that datum removed from the compilation, the values are nearly identical between the sexes for both the mean and the standard deviation of the distance that the tip of the racquet head moved from the onset of the forward motion of the backhand shot to the point of ball contact.

TABLE 2

Ball Height and Distance of Traveled of Racquet Head

| | Ball Height | | Racquet Head Distance | |
|---|---|---|---|---|
| | $\bar{x}$ (in.) | s.d. | $\bar{x}$ (ft.) | s.d. |
| Female | 14.62 | 4.92 | 6.78 | 0.50 |
| Male | 14.80 | 1.10 | 7.57 | 1.11 |

Table 3 reflects the mean linear ball velocities following contact for both groups of players. The male players hit the ball 18% faster than the female players, but both females and males were very similar within their groups. It is interesting to note that, of the male players analyzed in this study, three had participated in a previous study of the forehand stroke (Kent and Barlow 1979) and the linear velocities generated by the forehand stroke were only 1% greater than those generated in the backhand stroke.

The velocities of the racquet head were calculated at .01 sec. prior to contact and at the point of ball contact. The groups were very similar in the velocity of the racquet head at point of contact, both between groups and within groups. Only one male player had a negative acceleration during this period of measurement.

TABLE 3

Ball Velocities and Racquet-Head Velocities

| | Linear Ball Velocity | | Racquet-Head Velocities | | | |
|---|---|---|---|---|---|---|
| | | | .01 sec. Prior to Ball Contact | | Ball Contact | |
| | $\bar{x}$ (mph) | s.d. | $\bar{x}$ (mph) | s.d. | $\bar{x}$ (mph) | s.d. |
| Female | 89.19 | 4.11 | 65.26 | 10.31 | 86.45 | 4.75 |
| Male | 108.30 | 7.01 | 72.77 | 17.23 | 89.72 | 7.41 |

The data in Table 4 show the relationship of the position of the ball at the point of contact with leading foot, hitting shoulder and the center of gravity of the players. The locations of measurement for these variables are: the forward edge of the ball, the tip of the big toe, and the head of the humerus. The female players were striking the ball while somewhat further back toward the middle of the stance than were the male players. This seems self-explanatory since the females' stride lengths were longer than the males. Examination of the horizontal distance from the vertical line through the center of the shoulder to the front edge of the ball reveals that both the female and male players hit the ball when it was slightly in front of the hitting shoulder, with the female players hitting 12.2% more forward than the males. The distance from the vertical line through the center of gravity to the point of ball contact by the racquet shows that the female players were 16.4% closer to the center of gravity line when they hit the ball than were the male players (means were 9.36 in. and 11.20 in., respectively).

TABLE 4

Distance: Big Toe to Ball at Contact, Vertical Line from Shoulder to Ball at Contact and Center of Gravity Line to Ball Contact

| | Big Toe to Ball | | Vertical Line from Shoulder to Ball | | Center of Gravity Line to Ball | |
|---|---|---|---|---|---|---|
| | $\bar{x}$ (in.) | s.d. | $\bar{x}$ (in.) | s.d. | $\bar{x}$ (in.) | s.d. |
| Female | -.52 | 3.93 | 2.13 | 3.37 | 9.36 | 3.31 |
| Male | -.32 | 1.73 | 1.87 | 2.24 | 11.20 | 2.67 |

Examination of the data in Table 5 reveals that the stride length of the female players was 12.5% greater ($\bar{x}$ = 2.89 ft.) than for the male players ($\bar{x}$ = 2.53 ft.). The resulting ratio of stride length, measured big toe to big toe, to the height of the players shows that the ratio for female players ($\bar{x}$ = .53) was 18.8% greater than the ratio for male players ($\bar{x}$ = .43).

TABLE 5

Stride Length and Ratio of Stride Length to Standing Height

| | Stride Length | | Stride Length/ Standing Height | |
|---|---|---|---|---|
| | $\bar{x}$ (ft.) | s.d. | $\bar{x}$ | s.d. |
| Female | 2.89 | .46 | .53 | .07 |
| Male | 2.53 | .38 | .43 | .07 |

## DISCUSSIONS AND IMPLICATIONS

The high-level female and male players participating in this study demonstrated a high level of proficiency and skill of technique as recommended by teachers and professionals when hitting the backhand kill shot. The ball was struck considerably higher by the male players in comparison to the forehand kill. In a previous study (Kent and Barlow 1979), it was discovered that the backhand ($\bar{x}$ = 14.80 in.) was hit 269 % higher than the forehand shot ($\bar{x}$ = 5.51 in.) Both the female and male players in this study were hitting the ball well below the height of the knee, as is recommended by various technique books (see Cassady 1974; Fleming and Bloom 1973; Rich 1977; Verner 1977).

To convince the neophyte racquetball player that the backhand stroke is a full swing rather than a punctuated jab at the ball, the distance that the tip of the racquet travels from the initiation of the downward motion to the point of ball contact was measured. The average length of this range of motion for the female players was 6.78 ft.; for the men 7.57 ft. This certainly refutes the claim by Rich (1977) that the length of the backhand stroke should be no more than 2 ft.

The linear ball velocity appears to be related to the distance traveled by the racquet head and the velocity of the racquet itself at the point of contact with the ball. The male players generated greater linear ball velocity, had a longer range of motion of the racquet head, and had greater racquet velocities prior to and at ball contact than did the female players. It appears that the technique of bending the elbow and cocking the wrist at the beginning of the stroke is a very sound teaching strategy as this movement seems to facilitate the generation of racquet velocity. However, extending the arm during the swing prior to ball contact has the implication of increasing the range of the racquet head that can yield the result of greater ball velocity. It is interesting to note that highly skilled male players in this study had developed their abilities to the extent that there was virtually no difference between the ball velocities of their forehand and backhand shots.

Learning where the ball should be struck in relation to various body segments can be quite confusing to the beginning racquetball player. In this study, the high-level female and male players were hitting the ball when it was behind the big toe of the forward foot. Many technique books curtently in use today advocate hitting the ball when it is in front of the forward foot. Brumfield (1979) goes so far as to state that the ball should be struck when it is as much as 6 in. behind the shoulder (towards the middle of the stance). It is no wonder that learning the backhand shot is regarded as difficult by the beginning player. A teaching cue, suggested by the analysis of the data in this study, is to encourage the beginning player to hit the ball from such a position as to place the ball on a vertical line from the shoulder. This cue may be an easier concept for the beginner to grasp, rather than trying to encourage him to guess how far in front of his body the ball should be dropped in order to take an appropriate stride so that the ball is struck when it is just behind the big toe.

The consideration of the location of the center of gravity and the horizontal distance to the ball was not significant in the analysis of the backhand kill shot. This measure was very important, however, in the analysis of the forehand kill shot (Kent and Barlow 1979).

The stride length and resulting ratio of stride length to height was much smaller for the male players executing the backhand kill shot than for the forehand kill shot (Kent and Barlow 1979). The female players in this study had a stride length that was 18.8% longer than the males, suggesting that perhaps they were over-striding for the shot. The female players were striding 12.46% further than the males but were hitting the ball only 1.2% closer to the floor at the point of racquet contact with the floor.

## SUMMARY

Within the limitations and scope of this study, the data would appear to support the following statements and conclusions regarding the backhand kill shot by high-level players in racquetball.

1. Female and male players are comparable in hitting the ball a given height from the floor.
2. Swing technique yielding the greatest racket velocity starts with a bent elbow; then the arm is extended at the point of ball contact, resulting in a long range of motion determined by the distance traveled by the racquet head.
3. Practicing the backhand stroke and perfecting its technique will generate linear ball velocities comparable to those achieved by the forehand stroke.
4. Hitting the ball when it is in front of the forward foot is not a recommended hitting technique.
5. Hitting the ball when it is on the vertical line from the shoulder appears to emulate good hitting techniques as demonstrated by high-level female and male performers.

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# A RATIONALE FOR CARDIOVASCULAR ENDURANCE TRAINING IN THE RACQUET SPORT ATHLETE: A THERMOPHYSIOLOGICAL PERSPECTIVE

BY

Peter A. Hancock
Motor Behavior Laboratory
Institute for Child Behavior and Development
University of Illinois at Urbana-Champaign
Urbana, IL 61801

## Abstract

Three male athletes performed incremented work of basal metabolic rate (BMR) 100W and 150W in two levels of heat stress. Conditions inside the environmental facility were present at 25°C, 40% Rh and 30°C, 50% Rh (being 22°C and 29°C respectively, on the effective temperature scale). Expired air and six body temperatures, at two invasive and four skin sites, were monitored. Core and mean body temperatures, calculated from these figures, correlate highly with expired air for all the anthropometrically homogenous groups. Results are in agreement with unpublished data of Bungaard; ie., the higher the $VO_2$Max of the subject, the smaller the range of expired air values and the smaller the increase in both mean and core body temperature during heat stress. Such thermophysiological reactions helps the athlete to prevent the onset of mild hyperthermia and the accompanying fatigue, independent of mitigating behavioral support. The intermittent bursts of heavy physical activity required of the racquet sport athlete argue for a similar cardiovascular training regimen. Data from this study suggest that such athletes would be wise to augment training schedules with prolonged cardiovascular endurance work, especially when the possibility of competing in high ambient temperatures is foreseen.

Imagine a situation in which two racquet sport athletes of equal skill are engaged in a close contest. This competition continues for a considerable period of time and takes place in high ambient temperatures. Under such circumstances we may note that one competitor gains ascendency while his opponent succumbs to the conditions. Clearly, a complex relationship exists among many variables during such an event. It is possible to divide these variables into two general categories: physiological factors and psychological factors. Additionally, each of these may be subdivided into elements pertaining to the athlete and those related to the environment in which he operates. Although psychological elements are clearly important (Blyth and Lovingood 1964), physiological factors are the central focus of this study. Specifically, the author proposes a thermophysiological rationale for cardiovascular endurance training in the racquet sport athlete.

In the simple support of life the human body continues an activity level that produces some 70-75 kilocalories of heat per hour. During the intermittent bursts of physical exercise associated with racquet sports, this figure may reach or exceed 2,000 kilocalories per hour. Muscle temperature may rise as much as $6^{o}$C while vital internal temperatures may increase as much as $3^{o}$C. In order to rid itself of excess heat the body employs two basic effector systems: the first and most important is sweating, which cools the skin through evaporation; the second system, which acts in tandem with the first, it vasodilation, i.e., the blood vessels of the periphery enlarge to bring to the surface any heat in the blood which is then removed by both evaporation and conduction.

As sweat loss continues, body salt concentration rises and renal activity increases. Electrolytic concentration in the circulating blood eventually causes cessation of sweating. At this point, core temperature rises rapidly and severe hyperthermia or heat collapse quickly follows. The physical manifestations of heat exhaustion can range from mild fatigue to complete collapse, dependent upon the level of exercise and the existing environmental conditions. Such fatigue from hyperthermia can be a contributory physiological factor which limits performance. The experimental data reported here suggest a method of training which may help promote bodily mitigation of such debilitating heat storage.

## METHODS

Procedure. Each subject, wearing only shorts and training shoes (clothing insulation 0.1 clo) was introduced into an environmental chamber measuring 4.72 m. x 2.92 m. x 3.10 m. (approximate volume = 42.75 $m^3$). Subjects engaged in a monitored 12-minute pre-exercise phase and an 18-minute work phase at 100 watts followed by an 18-minute work phase at 150 watts. Two experiments were performed. In experiment 1, environmental conditions were set at 25°C, 40% Rh, $< 0.1$ $m.s^{-1}$ air velocity; in experiment 2, conditions were set at 30°C, 50% Rh, $< 0.1$ $m.s.^{-1}$ air velocity. These represent heat stress levels of 22°C and 29°C, respectively, on the Effective Temperature Scale, which synthesizes the dry bulb, relative humidity and air velocity figures. Such conditions were monitored from the chamber control panel, a WBGT Index Meter Min 3 Mach 5 Minilab and manually inside the chamber by use of a whirling hygrometer and Kata and Globe Thermometers. Subjects were tested after a three-hour period of food restraint and informed consent was obtained prior to experimentation (precise procedural and methodological details can be found in Hancock 1980).

Subjects. For the purpose of the study, three subjects closely approximating "standard man" (Dubois and Dubois 1915) were selected to form a relatively homogeneous group. Each subject participated in an English university athletic program at the inter-university level at the time of testing. Subject details appear in Table 1.

Table 1

Details of Subjects

| | | B.H. | S.T. | I.M. |
|---|---|---|---|---|
| Height | (cm.) | 170.0 | 169.0 | 166.7 |
| Weight | (kg.) | 64.5 | 62.45 | 66.10 |
| Age | (yr.) | 27.1 | 24.2 | 22.4 |
| Sex | (M or F) | M | M | M |
| Clothing Insulation | (clo) | 0.1 | 0.1 | 0.1 |

Temperature Recordings. Six temperature probes were used to monitor body temperatures. Four skin temperatures probes were attached to the thorax at two sites, immediately below the right scapula and on the sternum opposite the fourth intercostal space. The other probes were attached to the leg at the medial point of the right rectus femoris and to the arm at the medial point of the right biceps brachii. The rectal temperature probe was inserted to a depth of ten cm. A tympanic probe was placed adjacent to the tympanic membrane to avoid painful contact during work phases and a $0.1^{o}$C lag correction factor was introduced (Piironen and Aikas 1964). Temperature readings were monitored every two minutes during pre-work phases and every three minutes during working phases on a Light Laboratories ($5^o$-$40^oC$) six point thermometer.

Expired Air Recordings. Expired air during pre-work and work phases was monitored by a low resistance (100 L) Kafronyi Michaelis (KM) spirometer. The subject breathed into the meter via a flexible tube, low resistance non-return valve, and face mask.

## RESULTS

Three main parameters are used as assessments of body heat storage in each of the two experiments: (1) the observed increase in rectal temperature which reflected heat storage in the trunk core of the body; (2) a mean body core temperature increase, derived from weighted values of the two core temperature measures; and (3) a mean body temperature increase which encapsulates figures from each of the temperature sites and provides an overall index of bodily heat storage (see Table 2). In each condition the following holds true: the higher the $VO_2$Max of the subject, the lower the increase in the mean of the heat storage parameters; conversely, the lower the $VO_2$Max, the higher the rate of heat storage in the body. These data follow the pattern of Bungaard's (see Nielsen 1976) unpublished results from Neilsen's laboratory and find further support from the work of Mostardi, Kubica, Veicsteinas, and Margaria (1974).

Each subject in the present study was selected on the basis of similarity to a standardized model of the human being. The differences between heat storage are not attributed to anthropometric factors. Should subjects have differed in height, weight, surface area, or fat content, then temperatures reported may have been a reflection of such differences, although Bungaard

Table 2

Environmental Conditions

| | $25^{\circ}$C 40%Rh | | | $30^{\circ}$C 50%Rh | | |
|---|---|---|---|---|---|---|
| | B.H. | S.T. | I.M. | B.H. | S.T. | I.M. |
| Range $T_R$ ($^{\circ}$C) | 0.3 | 0.7 | 0.5 | 0.5 | 0.8 | 0.6 |
| Range Exp Air (L/Min) | 19.4 | 35.0 | 28.6 | 15.1 | 27.9 | 27.1 |
| Raw Data Correlation $T_R$ Vs Exp Air | 0.70 | 0.93 [a] | 0.85 | 0.59 | 0.84 | 0.84 |
| Mean Body Core Temperature [b] Increase ($^{\circ}$C) | 0.24 | 0.48 | 0.52 | 0.48 | 0.74 | 0.72 |
| Mean Body Temperature [c] Increase ($^{\circ}$C) | 0.30 | 0.62 | 0.94 | 0-83 | 1.04 | 0.88 |

[a] Raw data corrected for rectal probe movement artifact.

[b] Mean body core temperature increase ($MBCT_1$) calculated by:

(increase in rectal temperature x 4) + ( increase lympanic temperature) / 5

i.e., $MBCT_1 = (IT_R \times 4) + (IT_T) / 5$.

[c] Mean body temperature increase ($MBT_1$) calculated by:

$0.64\ (MBCT_1) + 0.36\ (MBST_1)$.

(Altered, after Burton and Edholm 1955

indicates a minimal importance for such factors. Rather, the subject who consistently engaged in cardiovascular endurance training was able to resist the onset of debilitating heat storage in a markedly superior manner, in both experimental conditions.

## DISCUSSION AND CONLUSIONS

There are two probable physiological reasons why athletes engaged in cardiovascular training are able to resist the onset of debilitating heat storage. During submaximal exercise the endurance-trained athlete, who is more accustomed to working at maximal levels, may utilize blood flow more effectively, supplying only the blood required by specifically active muscles. This would leave more blood available to take heat from core layers to be circulated through the skin. With more heat available for surface transfer to the environment, better regulation is achieved. Second, and more important, are the changes in peripheral vascularization and heart action associated with the physical overload produced by prolonged endurance training. The body of such a trained athlete may be better able to perfuse vessels near the skin layer during exercise. This perfusion, a forcing through the blood, is in part dependent on the state of vessels encountered. With endurance training comes increased vessel use and thus increased amenability to the passage of blood. The larger the surface area available for heat exchange at the surface, the better able the body is to rid itself of debilitating heat. The rate at which perfusion may occur is also dependent upon heart action, which is commonly facilitated by endurance training.

In most part, human beings effect temperature regulation by behavioral action. If we are hot we may switch on the air conditioner or remove layers of clothing; conversely, if we are cold we turn up the thermostat or assume a more heat-conserving position. In a racquet sport match, the competitor may towel off and take cold drinks to ease heat storage problems, but continuous use of these methods during a long match is neither desirable nor sufficient to alleviate all mild hyperthermic symptoms.

The racquet sport athlete generates a great deal of heat which must be dissipated from the body by activity alone. Greater strain is placed upon the athlete when the temperature in which he is playing is high and heat transfer away from the body is difficult. The best course of action is to boost the athlete's natural defense mechanisms against heat stress. Where the possibility of competing in hot environments is foreseen, the athlete should go through a period of acclimation. Specifically, this should entail continuous, graded training in the level of heat stress under which competition is expected to take place. Where training in hot environments is not available, yet playing in such conditions, through traveling, is a possibility, the coach would be wise to augment already existent training programs with cardiovascular endurance tasks. One of the simplest and best such tasks is continuous running, as compared to long-distance jogging; the former should contain a structure which ensures that the athlete is successively overloaded in progressive training sessions.

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# A FORCE PLATFORM STUDY OF OVERHEAD POWER STROKES IN BADMINTON *

by

Barbara A. Gowitzke
David B. Waddell
School of Physical Education and Athletics
McMaster University
Hamilton, ON CANADA L8S 4KI

## Abstract

The purpose of the present study is to analyze the ground reaction forces present during the performance of four overhead power strokes by elite badminton players. These players have been included in earlier studies of badminton power strokes using high speed bi-plane cinematography. The power strokes selected for analysis are the forehand overhead clear and smash and the backhand overhead clear and smash, with each player performing each stroke three times. Vertical reaction forces are of particular interest, although horizontal shearing forces are also studied. The vertical force patterns for each player's stroke repetitions are almost identical, and the inter-individual differences are minimal. Patterns for all power strokes indicate a marked "unweighting" and temporary airborne phase just before contact of racquet and shuttle. These results support observations made from cinematographical data recorded under laboratory and competitive conditions. It would appear that overhead power strokes are played with the body elevated to the extent that the feet are not in contact with the floor; thus a player cannot gain power for stroke execution from ground reaction forces. The implications for coaches and teachers are that emphasis on foot placement for overhead power strokes in badminton should be directed toward positioning, balance and recovery, not power.

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Cinematographic analysis of the technique of playing overhead power strokes has been the subject of a series of studies which were initiated by the authors in January 1975. As a result of these studies, some theories emerged regarding the extent to which the athlete is in contact with the ground during the execution of the power stroke, as well as the importance of ground contact. It was decided to test these theories by having the athlete perform power strokes while standing on a force platform designed to measure ground reaction forces in three dimensions. The power strokes selected for analysis were the forehand overhead smash and clear and the backhand overhead smash and clear.

## REVIEW OF THE LITERATURE

In previous cinematographic studies by the authors of overhead power strokes, some inference was made about elevation of the body at the point of contact with the shuttle, although this fact was not of prime concern to the objectives of the other studies (Gowitzke 1979; Gowitzke and Waddell 1977, 1979a, 1979b; Waddell 1977, 1979). Only in the detailed analysis of the forehand smash was specific reference made to foot contact with the ground and extent of elevation of the body: "The players were 'airborne' at the moment of the racquet's impact with the shuttle. The height attained during the smash varied with the player and, to some extent, with the placement of the player relative to the shuttle, but no foot contact with the floor was evident" (Gowitzke and Waddell 1979b: 11).

Jack and Adrian (1979:40) also cite the prevalence of elevation during the performance of the smash and conclude: "The data from this sample show that the jump is an important component of the badminton smash of excellent badminton players." It is important to note that the Gowitzke - Waddell and the Jack-Adrian analyses were directed toward the performances of Commonwealth Games athletes on court, in competitive conditions, where a variety of smashes were observed, ranging from those using minimal elevation to those usually described as jump smashes.

A survey of the many books describing the game of badminton leaves the authors with the impression that overhead power strokes must be played so that the feet are in contact with the ground through impact with the shuttle. Further, there is general agreement that a loss of power ensues if contact with the ground is not maintained. Many books describe a weight transference from the back foot to the front foot, and the authors conjecture that there would be a general concensus among the participants of this conference that ground contact and weight transference is crucial to power in the stroke. For example, Davidson and Gustavson (1953:19) in their excellent treatise, write: "To insure that maximum power can go forward into the stroke it is absolutely essential that the body weight be smoothly transferred forward from the back foot to the front foot. At the moment of impact between shuttle and racket, the body, leaning forward a little toward the shuttle, is perfectly balanced on the front foot, with the toe of the back foot about to leave the floor."

More recently, Davis (1967:45) describes the advantages and disadvantages of the jump smash: "It is played exactly as the normal smash except that at the moment of impact both feet are off the ground . . . thus you have no real foot-purchase for power . . ." Speaking generally of the power strokes, Davis (1967:34) also states: "The body weight should be taken back sideways on to the rear foot as the racquet swings back. When the racquet starts on the forward swing, the body weight should start to move from the rear to the front foot. As the shuttle is hit, the body having pivoted at the hips, should be moving powerfully forward over the front foot. This easy swing of ten or a dozen stone [140 to 168 lbs.] obviously imparts power to the stroke and helps the player move into position for his next one." Finally, Downey (1969:25) covers basic points to be kept in mind for the overhead forehead clear which include the following: "Prepare for the stroke, weight on the rear foot and racket held back with the wrist cocked; throw upwards to full stretch height and allow the body weight to transfer forwards on to the front foot; keep both feet in contact with the ground."

## PROCEDURE

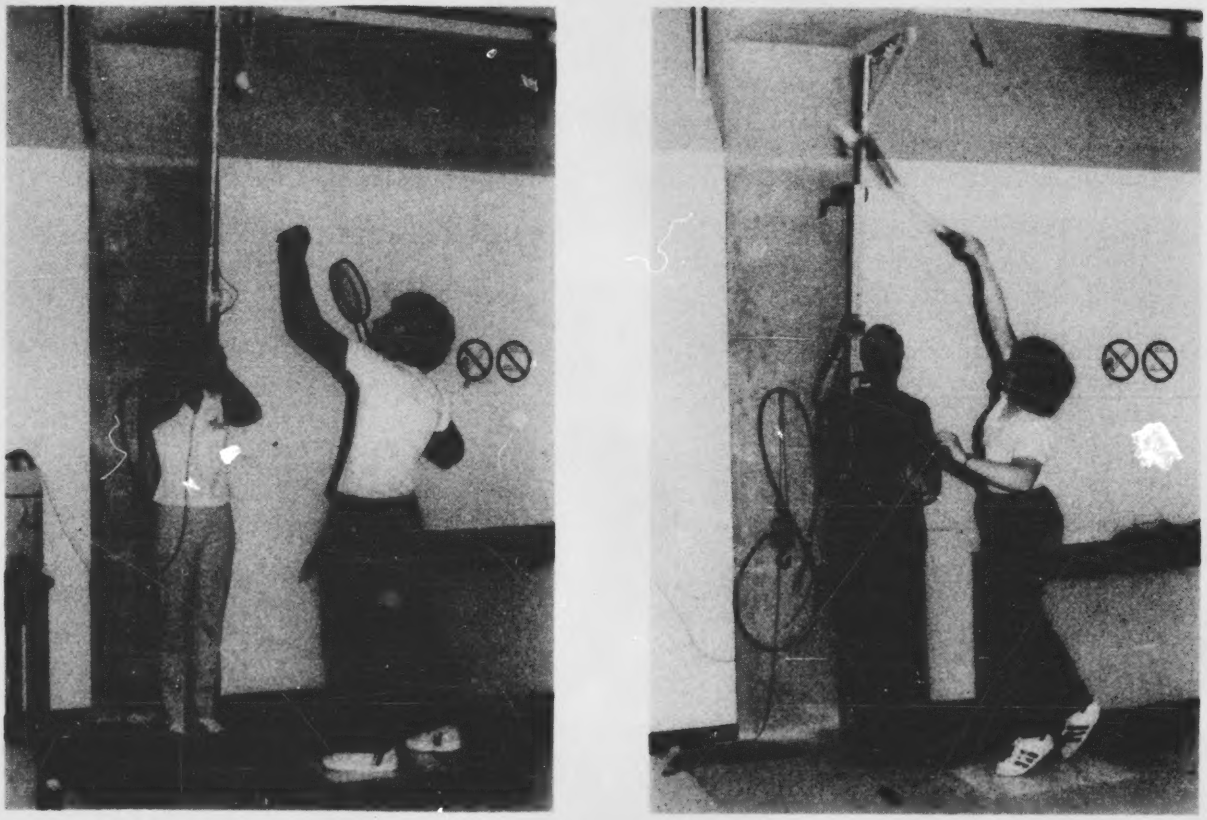
The purpose of the present study is to analyze the ground reaction forces present during the performances of four overhead power strokes played by four elite badminton players (two males and two females, two right-handed players and two left-handed players). Three of these players have been included in earlier studies of badminton power strokes using high speed biplane cinematography. The power strokes selected for analysis were the forehand overhead smash and clear and the backhand overhead smash and clear. Each player performed each stroke three times. Reaction forces in three demensions were recorded; the vertical reactions force was of primary interest for this study, although the horizontal shearing forces (forward-backward, right-left) were also noted.

A Kistler force platform coupled to a Honeywell oscillograph was the principal measurement instrument. The force platform was anchored to the floor in a room with a ceiling height of approximately three meters. The ceiling height limitation made it impossible to project a shuttle to the performer; instead a shuttle was suspended from a constructed support with its cork down, in the position designated by the player to be his/her planned position of contact with the racquet (Figure 1). A standard tape recorder microphone, also suspended from the support in a position approximately 20 cm. above the shuttle, was coupled to an A-C amplifier and linked to the recorder to provide a visual record of the abrupt noise made when the racquet struck the shuttle. In this way, the recordings of the three components of force could be analyzed.

The recording paper speed was 50mm./sec. Two millimeters (one-division) of deflection on the vertical reaction force channel represented 16.67 lbs. (74.17 Newtons). A check of the calibration was made for each subject by first weighing the subject on a balanced scale and then "weighing" and recording the subject's weight on the force platform. For example, if the subject weighed 132 lbs. (587.4 Newtons), then the recording would be expected to deviate 16mm. when he/she stood on the force platform.

## RESULTS

Data on the four athletes who participated in the study are provided in Table 1. A recording of the shuttlecock velocity resulting from the forehand smash is also provided for three of the players involved in a 1978 study.



(a) (b)

Figure 1. Experimental arrangement of athlete, force platform, suspended shuttlecock and microphone.
(a) Subject #3 in the "ready" position, prior to performance.
(b) Subject #2 during contact with the shuttle.

Table 1

Descriptive Data of the Four Badminton Players

| Number of the player | Right- or Left-handed | Male or Female | Body Weight lbs. (Newtons) | Velocity of Shuttle (Forehand smash)[a] mph (m./sec.) |
|---|---|---|---|---|
| 1 | left | female | 132<br>(587.4) | 124.6<br>(55.7) |
| 2 | right | female | 147<br>(654.2) | 146.3<br>(65.4) |
| 3 | right | male | 163<br>(725.4) | 162.6<br>(72.7) |
| 4 | left | male | 166<br>(738.7) | data not available |

[a] Shuttlecock velocities of the forehand smash were measured by the authors in a 1978 study, 25 sec. after contact with the racquet.

The vertical components of force patterns for each player's stroke repetitions are almost identical for each of the strokes analyzed. Even inter-individual differences for each of the four strokes are minimal. Patterns for all power strokes indicate the following: (1) a preliminary unweighting phase, when the athlete initially flexes the lower extremities and starts a downward movement of the body; (2) a marked weighting phase, when the athlete completes the downward movement and moves almost to the end of the upward movement of the body; (3) a final unweighting phase, to the point of being airborne just before contact of racquet and shuttle; and (4) a secondary weighting phase after contact, when the athlete once again contacts the force platform and starts to decelerate the vertical motion of the body to stop (Figure 2). These results support observations made from cinematographical data recorded under laboratory and competitive conditions that the player's body is elevated to the point of minimal or no contact with the group impact.

The pattern of all four strokes is strikingly similar to the timing and phases of vertical components of force recorded for the vertical jump described by Miller and East (1976). The difference between the vertical jump and the badminton power stroke is seen only in the amplitude of the vertical reaction force in all phases described, the jump showing about twice as much weighting force. The similarity of patterning between the badminton stroke and the jump is somewhat surprising considering that the precise objective for the player is to hit the bird, not to jump. Indeed, the similarity underscores the emphasis on elevation of the body for all overhead power strokes. Undoubtedly, the performance of an intended jump smash would approximate the amplitude recorded for the vertical jump and would retain the temporal characteristics of the phases described above.

Differences among subjects are minimal. Differences in the amplitude of the vertical reaction forces are noticeable between the men and the women, with the men showing larger amplitudes in all phases of the strokes. It is of interest that the first subject used little, if any, preliminary unweighting in all of the strokes. There is a suggestion of a correlation between amplitude of preliminary unweighting and velocity of the shuttle in the forehand smash, thus indicating a need for further investigation.

Differences among strokes are also minimal. The two smashes, forehand and backhand, display the greatest amplitudes in all of the phases, and the forehand clear shows the least amplitude (and the greatest variance among

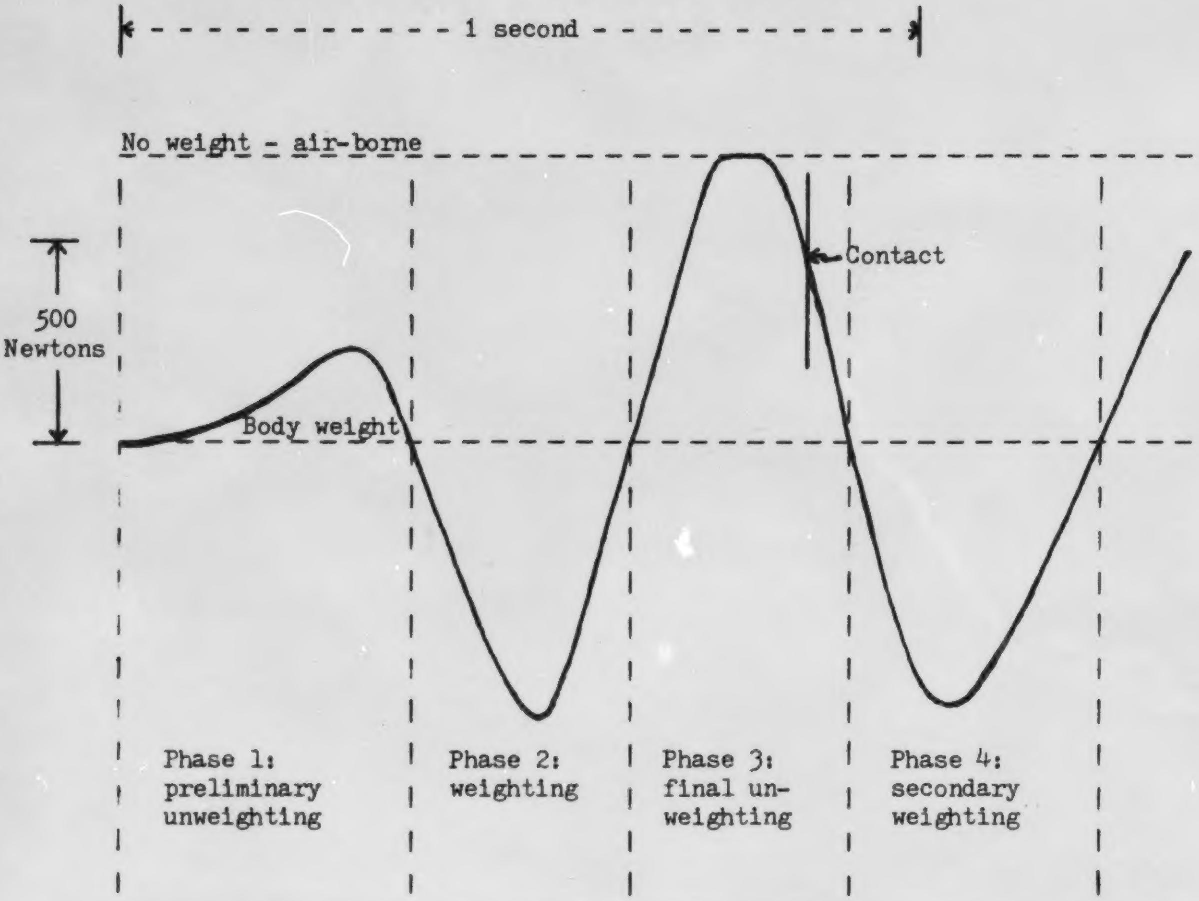


Figure 2. A sample recording of a vertical component of force pattern exhibited in badminton power strokes.

players). All players displayed a final unweighting, to the point of being airborne, in the forehand smash before they contacted the shuttle.

## CONCLUSIONS

Although this sample of elite badminton players is small, the results of this study show that all overhead power strokes are played with the body elevated; for the forehand smash, the feet were not in contact with the ground. Thus a player may gain power for body elevation, but cannot gain power for stroke execution, from ground reaction forces. These results support observations of the authors that every smash is a "jump smash" whether or not the player intentionally jumps for it.

In the literature on overhead power strokes, foot placement and transference of weight from the back to the front foot are considered essential to the development of power. The emphasis should be placed on foot placement for positioning on court, balance, and for jumping and recovery, not for power.

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# SKILL ACQUISITION

# AND

# TEACHING STRATEGIES

# ADAPTED STROKE TECHNIQUES IN ADVANCED TENNIS INSTRUCTION

by

Guncars Tilmanis
Portland, OR

Over the many years of tennis development, much has been written on the acquisition of mechanically sound strokes, physical fitness and efficient court movement, mental fitness, the development of self-confidence, and the development of sound tactics. Very little has been offered in regard to what could be termed "adapted tennis." Adapted stroke technique is a player's ability to adapt his body position, racket swing, or ball contact point to compensate for being off-balance, out of position, or under the pressure of a ball approaching with excessive speed or spin.

Should a player always attempt to hit a ball with classic form? The answer is "No!" More often than not a player who is caught off-balance or out of position, and who stubbornly attempts to hit the ball with the same aggressiveness and classic technique he would use if he were in position, will make many errors. An adapted stroking technique is necessary.

## INTRODUCTION

Do you want to look good or get the job done? If you have the time, get comfortable and look good (classical form), since it will give you the greatest chance of success. This is also the time to hit the shot adventurously. When under pressure, however, and there is little time to get comfortable, just get the job done, i.e., be happy to hit the ball back. Now is not the time to hit the ball adventurously.

## A LOGICAL TEACHING PROGRESSION

A coach must obviously first teach a comfortable, classical stroke. But he then owes it to his student to tell him of the major adaptations need to handle the variety of shots he will be forced to hit in a game situation. Adapted tennis techniques must be taught. One of the key responsibilities of a coach is to short cut a player's learning time.

## ADAPTED STROKE TECHNIQUE AS APPLIED TO TEACHING THE BACKHAND

The seven major adaptations are: (1) comfortable, classic shot (from the base line); (2) ball coming directly at a player (from the base line); (3) short ball (landing in the service court); (4) high bouncing ball (landing on the base line); (5) chasing a wide ball; (6) balls approaching with varying speeds and spins; and (7) rallying in game-like drills. Practical situations in which a player has to make body, racket swing, or ball contact adjustments to compensate for being off-balance or in a position from which it is not wise to hit adventurously include: (1) hitting the ball from various court positions; (2) hitting the ball at varying contact points; (3) hitting the ball when out of position or off-balance; (4) adjusting to various ball speeds; and (5) practicing shots or situations which do not occur very frequently in the game situation.

## CONCLUSION

"Do you want to look good or get the job done?"

# SUCCESS IN TENNIS: KEEP THE BALL IN PLAY

by

Larry D. Hensley
University of Northern Iowa
Cedar Falls, IA

Candy Norton
University of Georgia
Athens, GA

## Abstract

The purpose of this study is to relate stroke efficiency, as determined by the incidence of errors committed, to match performance. Data were collected during direct observation of the 1978 and 1979 Tennis Championships. Specific information was obtained regarding the incidence of stroking errors and outright winners as well as factors related to each of these. The overall results indicate that stroking errors outnumbered placements by a 2 to 1 margin and that errors accounted for approximately 67 percent of all points won. The performance patterns of those players surveyed indicate that the forehand stroke is more reliable (i.e., the ratio of errors to placements for the forehand stroke was 1.3 to 1, whereas the ratio of errors to placements for the backhand stroke was 2.5 to 1). In addition, forehand strokes accounted for significantly more placements than backhand strokes -- 62 percent of all placements -- while accounting for only 46 percent of all the stroking errors committed. The major implication of this study is that the key to being a successful competitor in tennis is the ability to keep the ball in play, not the ability to hit winning shots.

The popularity of tennis has been unprecedented during the past 10 years, with an estimated 40 million Americans currently playing the game (see U.S. News and World Report, 15 January 1974). During this time period there has been a multitude of successful players; but only a handful reach the pinnacle of success, as demonstrated by winning Wimbledon or the U. S. Open. What is it that highly successful tennis players have in common that contributes to their achievements on the tennis court? Are they superior athletes? Do they stroke the ball the same, utilize the same game plan, or exhibit the same mental approach to the game?

Considerable research into the biomechanics of the stroking patterns used in executing the various shots has been conducted during recent years. Although this information has increased our knowledge regarding the physics of hitting a tennis ball, a look at the top ten players in the world clearly shows that each uses a different stroking style. This is not to say that there are no similarities in their strokes, it merely points out that there is a "range of correctness" in which the skilled performer may execute the various shots. There are certainly a number of factors which contribute to one's success in tennis, regardless of the skill level. Playing "percentage tennis," however, can significantly improve one's chances of success, whether the world title or the championship in one's tennis class is at stake. But exactly what is "percentage tennis"? What percentages are so important that they can help win a tennis match?

The purpose of this study is to examine the components of "percentage tennis" and delineate those components most representative of play among highly skilled performers. Specifically, an attempt is made to relate stroking efficiency, as determined by shot sequence, incidence of errors committed, and winning placements to match performance. Data were collected by incidence charting during direct observation of matches at the 1978, 1979, and 1980 NCAA Tennis Championships. These championships included 64 of the best amateur tennis players in the world each year. It should be noted that these matches were played on hardcourts and that no-ad scoring was utilized. The idea of incidence charting is certainly not new to tennis: virtually every tennis coach has developed a systematic charting technique to assess strengths and weaknesses of his/her players and to scout opposing players; however, obtained data are often too limited to serve as the bases of broad generalizations. The cross-sectional data obtained in this study provide an empirical base for such generalizations and interpretations.

It has been previously reported (Hensley 1979; Tilmanis 1975; Van der Meer 1976; Van Horn 1964) that points scored during a tennis match are won predominantly on errors rather than by winning placements. The findings of this study indicate that 65-70% of all points scored in a tennis match are due to errors (Table 1). This clearly supports previous findings, although the percentage of errors is slightly less. The performance patterns of those players surveyed indicate that stroking errors outnumber placements by 2 to 1 and that match winners made 16% fewer errors, on the average, than did the losers of the match, while hitting 18% more winning placements. It is also noted that approximately one-fifth of all errors were committed on service returns.

Table 1

Classification of Points Scored

| | Number | Proportion of Total Points (%) |
|---|---|---|
| Errors | 3359 | 65 |
| Placements | 1804 | 35 |

Backhand strokes accounted for 54% of all stroking errors, thus lending credence to the idea that the backhand stroke is normally the weaker stroke and thus should be exploited. As expected, crosscourt shots were the most reliable, accounting for only one of every three errors. The percentage tennis player should therefore be aware that the probability of making an error doubles when attempting a down-the-line shot. A comparison of the proportion of crosscourt and down-the-line errors for both forehand and backhand shots, is shown in Table 2.

Table 2

Proportion of Total Errors Relative to Shot Type

| | Crosscourt (%) | Down-the-Line (%) |
|---|---|---|
| Forehand | 17 | 29 |
| Backhand | 20 | 34 |

The net is the foremost obstacle facing any player attempting to hit the ball in the court; a fundamental requirement for keeping the ball in play at any level of tennis competition is to first hit the ball over the net. More mistakes are committed by hitting the ball into the net than by all other types of errors. Shots hit into the net accounted for viturally one-half (48%) of all errors committed, while those going long or wide accounted for 31% and 21%, respectively (Table 3). Perhaps this is why more and more of the good players in the world are hitting heavy topspin shots, thereby permitting the ball to carry well above the net and still fall with the court. Recognizing the associated probability of error, players should be encouraged to hit out on the ball,

Table 3

Proportion of Total Errors Relative to Error Type

| | Long (%) | Wide (%) | Net (%) |
|---|---|---|---|
| Forehand | 16 | 9 | 21 |
| Backhand | 15 | 12 | 27 |

striving for a high net clearance. This also has strategical implications: by forcing the opponent to return shots from deep in the backcourt, the advantage gained by advancing to the net following a short shot is controlled.

With regard to stroking efficiency, tournament participants hit approximately 62% of their first serves into the proper court. There is virtually no difference in first-serve percentages between match winners and match losers. It is also noted that players double-faulted only once in every 25 serves. An analysis of all ground strokes hit during a match indicates that 15 ground strokes must be hit for each ground stroke winner, whereas every fifth ground stroke resulted in an error being made. This means that for every ground stroke a player hits, the chances of committing an error are three times as great as compared to hitting a winning placement. When hitting a volley, however, the chances of hitting a winner as opposed to making an error are about even. In contrast to an efficiency rate of 15 to 1 for ground stroke winners, about 20-25% of all volleys result in outright winners. This finding suggests that a significant advantage may be gained by advancing to the net. When hitting a volley, a player reduces by 20% his probability of making an error, while at the same time improving by threefold his/her chances of hitting a winning shot.

Although a three-set tennis match between highly skilled players often lasts as long as two hours, the typical hardcourt point involves only three strokes, including the serve (but not including the stroke on which an error is made). The fact that the serve and service return comprise two-thirds of all strokes used in a typical point illustrates the importance that should be placed on these two shots. Even though the average point lasts only three strokes, the findings of this study suggest that the longer a point lasts, the greater the chance of a winning placement to win the point.

In conclusion, the findings of this study provide empirical evidence to support the concept of "percentage tennis." The implications suggest that the key to successful tennis is keeping the ball in play, not necessarily hitting winning shots. In order to become a highly successful tennis player, one must simply hit the ball in the court one more time than the opponent does. The accomplishment of this goal may be enhanced by an understanding of the relative importance of the various shots and their probabilities of success.

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# A COMPARISON OF SKILL ACQUISITION BETWEEN THE PART-METHOD AND WHOLE-METHOD OF SERVING WHEN LEARNED BY NOVICE TENNIS PLAYERS

by

Jack L. Groppel, Ph.D.
Fontaine Piper
Linda D. Pecore
E. Keith Milner, Ph.D.
Biomechanics Research Laboratory
117 Freer Gymnasium
University of Illinois at Urbana-Champaign
Urbana, IL 61801

## Abstract

When learning the tennis serve, an individual can be presented with several different teaching methods which are thought, in the opinions of the instructors involved, to best facilitate skill acquisition. Two methods have commonly been utilized to teach the mechanics of the serve: the half-swing (part-) method and the full-swing (whole-) method. The purpose of this investigation is to compare skill acquisition between the whole- versus part- method of teaching the tennis serve and also to study how differences in court position at the beginning of the learning process affect skill acquisition. Beginning tennis students in the Physical Education Activity Program at the University of Illinois (n=120) were studied. Pretest and posttest performances were measured with an intense instructional and practice session between each testing session. The results of the study indicate more skill improvement when the students began with the part- method and gradually transferred to the whole- method. No differences can be observed in skill acquisition by varying the court position (close to the net versus serving from the base line) of the novice players.

Many tennis teaching authorities have noted the serve as the most important stroke in the game. This seems a plausible statement since the serve begins each point and is the method by which a player can start an offensive attack; if not executed properly, however, the serve can be used by the opponent to control the point and place the server on the defensive. Therefore, it seems imperative that anyone wishing to improve their tennis-playing abilities should spend a considerable portion of their learning experiences developing the technique of their serve.

When learning the tennis serve, an individual can be presented with several different teaching methods which are thought, in the opinions of the instructors involved, to best facilitate skill acquisition. Two methods have commonly been utilized to teach the mechanics of the serve; the half-swing (part-) method and the full-swing (whole-) method. Professional tennis instructors continue to debate which is more advantageous: to teach the whole-method (full-swing) from the beginning of the learning process or to teach the part- method (half-swing) in the beginning and graduate to the full-swing motion later in the learning process (Braden 1978; Groppel 1980; Murphy 1958; Van der Meer 1975).

Regardless of the teaching technique used, one major problem may still exist, that of being successful with the serve. Even if the student has an efficient serving motion, it is useless unless the ball lands within the proper boundaries and affords the individual some feeling of success. To facilitate success with the tennis serve, Van der Meer (1975) suggests that the student begin learning the serve from a position closer to the net than the base line (i.e., the service line). His rationale is that this positioning allows the student more success in serving in the beginning stages of the learning process, thus providing the individual with more confidence for hitting successful serves from the base line at a later time.

With the aforementioned in mind, the purpose of this investigation is to compare skill acquisition between the whole- versus part- method of teaching the tennis serve and also to study how differences in court position at the beginning of the learning process affect skill acquisition.

## REVIEW OF LITERATURE

Most skills can be taught either by dividing them into component parts or considering them as a whole. Depending upon the nature of the activity, a component can be taught as a whole or again subdivided. Baseball, basketball, tennis, swimming and football are a few examples where the whole must be divided into component parts so as to facilitate learning. In all of the sports previously mentioned, the player is instructed in each aspect of the game and then each component is integrated into the overall game. This concept is widely understood and accepted. The continuing problem, however, is how many parts a skill should be divided into before the learning is retarded rather than enhanced.

The part-method of skill acquisition usually denotes that the skill is broken down into equal components and each component is practiced an equal amount of time until the entire skill is mastered. A new component is not introduced until the previous one is mastered. A variety of methods have been utilized when attempting to teach in this way. The tennis serve, for example, is part of the overall game. The question that needs to be answered is whether the serve should be taught as a whole (full-swing method) or broken down into parts (i.e., the half-swing method). There are two considerations when trying to determine whether the whole- or part-method should be utilized: the task complexity and the task organization.

Wickstrom (1958) examined gymnastics skill by instructing one group of students by the whole-method and another group by the part-method and found no significant differences in total skill acquisition between the groups. Neimeyer (1959), however, found that it varied with the skill. Neimeyer found that volleyball is best learned by the part-method, swimming by means of the whole-method, and badminton by either method. The results of that investigation seem to substantiate the task complexity/task organization concept. Thus, tennis may be considered to be high in task organization and high in task complexity, further complicating the issue as to which instructional method may be more conducive to skill acquisition by the student.

Research dealing with the most effective method of teaching the service is virtually nonexistent. The development of the various methods presently being utilized has been through the efforts of teaching professionals who have adapted their teaching methods to accommodate the ability levels of their students. Tennis authorities have commonly shared their instructional techniques at clinics and through articles appearing in popular magazines, but the obvious problem is that all of these professed methods are experientally based; no empirical data exist depicting which technique (part-method versus whole-method) might better facilitate skill acquisition during the early stages of learning.

The part-method serve requires the least amount of coordination by the student. The student assumes the normal serving stance, which begins with the front foot at approximately a $45^{\circ}$ angle to the base line. The player then positions the racquet over his/her shoulder as if attempting to scratch his/her back. Once this position is assumed, the player is ready to toss the ball. The ball should be tossed so that it will reach a height slightly greater than the server can reach with the arm and racquet fully extended upward. The ball, if allowed to drop after the toss, should land within six inches of the server's left foot. When attempting to make contact with the ball, the striking arm should be fully extended over the head and slightly in front of the base line. If contact is made in the center of percussion of the racket ("sweet spot"), the opportunity for success will be increased.

The full-swing serve has the same forward swinging motion as the part-swing service. The difference is in the movement of the striking arm to the back-scratching position. The motion is similar to that of a pendulum with both arms moving toward the ground together. The striking arm then moves posteriorly in the sagittal plane while the tossing arm moves anteriorly in the sagittal plane. The striking arm continues its movement until it is approximately parallel to the ground, at which time the elbow is flexed and the forearm is raised to its highest possible position. The tossing arm continues its movement upward, releasing the ball at the appropriate instant to obtain the same release as desired for the part-swing service. The player then swings at the tossed ball with the striking arm and tries to make contact in the racquet's center of percussion with the body in near total extension.

Disagreement always seems to exist as to whether the full-swing method is more advantageous than the half-swing method when teaching beginning players. Gensemer (1975) indicates no mechanical advantage to the full-swing method and notes that a number of professionals are using a motion similar to a half-swing technique. According to Gensemer, the important performance objective is arriving at the back-scratching position and continuing the upward movement without a distinct pause (or hitch) in the development of momentum in the swing. He also contends that since the half-swing method is the technique used in the overhead smash, the server is practicing the smash every time he serves and is practicing the serve each time he hits an overhead shot. Broer (1973) arrives at just the opposite conclusion, contending that significantly greater force production is available with the full-swing method and that, while the half-swing method is easier to use because less coordination is involved, the loss in effectiveness is much greater. Alternatively, the coordination problem associated with the full-swing method may cause a reduction of force and control on the ball, inferring that it may be better to allow the student to begin from the back-scratching position so as to achieve earlier success.

The question as to whether the whole- or part-method is most beneficial in learning the serve seems to still be unresolved. If students have a difficult time learning a complete-swing motion, one answer may be to teach the part-method. In any case, teaching the serve could be enhanced if it were determined that skills were definitely acquired faster in the early stages of playing tennis by using the part-method.

## METHOD

Subjects. Subjects for this investigation were 120 volunteer students from eight randomly selected Tennis I classes at the University of Illinois. During the first class session these individuals were informed of the experiment and how they would be involved. It was emphasized that participation was voluntary and that those who volunteered should have had extremely little tennis-playing experience, i.e., less than ten previous tennis experiences on the court in their lifetime.

Procedure. Prior to any instruction, all students were pre-tested. Each was positioned near the intersection of the base line and center mark and requested to "serve the ball in an overhand pattern, similar to throwing a ball." After one practice serve, the subject was to hit eight serves from either right to left or from left to right, depending on how each was randomly assigned (this was done to avoid any learning effect). Serves were recorded as being either in or out of the service court and form was also assessed by two NCAA Division I tennis coaches and one AIAW head tennis coach. Following the eight serves, the student was positioned on the alternate side of the center mark and instructed to hit eight more serves to the opposite service box. Scoring was done as before, judging accuracy and form. All subjects were evaluated on a form scale of 1-5, with 5 being the best score. Judges scored subjects' form in terms of (1) lower-body movement, (2) upper-body movement, (3) smoothness of preparatory phase, (4) ball toss efficiency, and (5) upper- limb movement throughout impact and follow-through.

Following the pre-test, six classes were randomly assigned to an experimental group, while the remaining two classes were identified as a control group. The control group consisted of two classes taught by the whole-method of serving with students serving from the base line (n=34). Of the experimental group, two classes each were taught by the following methods: (1) part-method of serving with students beginning at the service line (n=23);

(2) part-method of serving with students beginning at the base line (n=39); and (3) whole-method of serving with students beginning at the service line (n=24).

The categories of tennis instruction were twofold: (1) part-method versus whole-method instruction and (2) service line versus base line instruction. The part-method classes began by learning the half-swing service first and practicing it under instructor supervision for three class periods, then switching to the whole-method for four class period (Table 1 depicts the scheduling of instruction and practice). The whole-method classes obviously were taught the full-swing and practiced it for all seven class periods. Those classes beginning at the service line practiced in that position for two class periods, then moved halfway between the service line and base line for two class periods, and finally served from the base line for two class periods.

To administer the maximal amount of experimental controls, all service instruction was done by two instructional supervisors, each having a minimum of fourteen years of tennis-teaching experience. Exact teaching strategies were discussed and practiced prior to the instructional sessions. These teachers were present at all times during service instruction to monitor and criticize the serve and to answer any questions.

During the time period of the investigation, students were requested to restrict their practice times to only three hours per week outside of class. It was emphasized that a maximum of one hour per week should be spent practicing the serve. These requirements did not seem unreasonable since all subjects were enrolled as full-time academic students and practice time would be limited. All participants agreed to these practice limitations

Table 1

FOUR-WEEK SCHEDULE (SERVE ONLY)

| | DAY 1 | DAY 2 |
|---|---|---|
| 1st WEEK | 1. Introduction<br>2. Consent form completed | 1. Pre-test (weather permitting)<br>2. Forehand instruction |
| 2nd WEEK | 1. Tennis serve instruction<br>2. Questions and answers/serve | 20 minutes/serving (10, r-l; 10, l-r)<br>1. part base line<br>2. whole base line<br>3. part service line<br>4. whole service line |
| 3rd WEEK | 20 minutes/ serve (10, r-l; 10 l-r)<br>(same as previous day) | 20 minutes/ serve (10, r-l; 10, l-r)<br>1. part base line<br>2. whole base line<br>3. part halfway between service line and base line<br>4. whole halfway between service line and base line |
| 4th WEEK | 20 minutes/serve (10, r-l; 10, l-r)<br>1. whole base line<br>2. whole halfway between service line and base line | 10 minutes/ serve (10, r-l; 10 l-r) |
| 5th WEEK | 20 minutes/serve (10, r-l; l-r)<br>(same as previous day) | post-test |

at the beginning of the experiment. At the end of the fifth week, the subjects were post-tested in an identical fashion to the pre-test procedure. All accuracy and form evaluations were tabulated for statistical analysis. A treatment (teaching method)-by-treatment (location on the court) design was used to test which method improved skill more. The level of acceptability was set at $p<0.05$.

## RESULTS AND DISCUSSION

To assess the reliability of subject ability in tennis serve, the pre-test data were compared between groups. Since no significant differences were determined, it is concluded that no experimental error existed as a result of group differences in serving ability.

With regard to the type of service taught, it is observed that both service types (beginning with either the part-method or whole-method) yielded significant improvement from the pre-test data in terms of accuracy and form. Significantly greater improvement in accuracy (not form) is noted when the subjects began the tennis serve using the part-method and graduated to the whole-method of serving. These findings concur with the contentions of Gensemer (1975), who professes usage of the part-method of serving, but they disagree with Broer (1973), who states that the greater force production from the whole-method benefits the learner more than the part-method and also prevents the lack of effectiveness received from the part-method. The effectiveness of either serve method can not be addressed from this study, but it seems noteworthy that the students were more successful at the end of the five-week period when they began with the part-method.

No significant form differences were determined between the two types.

This seems plausible since the time required to gain efficient form is much greater than only the five weeks examined for the purposes of this investigation. In fact, Braden (1978) concludes that success in serving is not necessarily dependent upon good form and movement efficiency.

Success being considered as an important concept, subjects were also divided into two location groups: one serving from the base line for the entire five-week period and the other beginning the serve at the service line and gradually moving back to the base line. No significant differences can be determined for accuracy or form between these two groups. This finding refutes the recommendation of Van der Meer (1975) to start the student serving from a position closer to the net than to the base line. In fact, our results indicate that it makes no difference where the student stands to serve since success of serving will be similar over a five-week instructional session.

If tennis instructors accept the theory that it is extremely important for the student to feel some measure of noticeable success (i.e., hitting a good serve within the service court boundaries) during the early stages of learning, then most tennis students should begin the serve using the part-method. Graduation to the whole-method could be based on partial or total success with the part-method, depending on the instructor. Using this process, the student will most likely succeed in the tennis serve at an earlier stage in the learning process.

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# EXPLORING TEACHING BEHAVIORS OF UNIVERSITY TENNIS INSTRUCTORS

by

John L. Taylor
E. Keith Milner
University of Illinois at Urbana-Champaign
128 Freer Gymnasium
Champaign, IL 61820

## Abstract

In this study we investigate the relationship between college students' and instructors' perceptions of the instructors' effectiveness in using eight selected teacher behaviors during the teaching of tennis. As a descriptive study, behaviors said to be important for teaching students were recognized and considered "more" or "less" effective by teachers (n=16) and students (n=297) during an eight-week tennis session. On the session's second, fourth, and seventh weeks, six raters (with inter- and intrarater reliability scores ranging from .90 to .94) used the Physical Education Observation Instrument (PEOI) to observe instructors for 30 minutes. Also, during the final week of classes students and teachers completed questionnaires with items addressing the eight behaviors. The PEOI frequency counts averaged over classes are used as outside validation of teacher behavior occurrences and show that teachers varied in their use of behaviors. Average teacher behavior frequency observations are plotted as a result of the lack of agreed indices between teachers and students. The results show variability of teachers on three occasions. To separate teachers as "more" or "less" effective, student questionnaire rating results are used and compared to teachers' average frequency counts. The "more" or "less" effective teachers are evident. This indicates that students and observers agreed in identifying teachers who do or do not effectively use the right behaviors. The results show that students do recognize and consider what behaviors teachers use during instruction. The indication is that the average students' scores and teachers' self-scores have moderate relationships on two behaviors, managerial engagement ($r=.6434$; $p<.05$) and demonstration ($r = .4115$; $p<.05$). Six behaviors show no relationships between teacher and student scores.

This study was undertaken to discover if teachers and students perceive the degree to which more effective and less effective teacher behaviors occur during the instruction and learning of tennis in college-level courses. For these purposes, such information may assist teacher educators and administrators in improving the instructional processes in teaching tennis.

In recent years a number of tennis teaching techniques and methods have been successfully introduced. However, the study of teacher behaviors relating to tennis has not been of interest and is not a popular subject in research. Although research on teacher behaviors in sports and physical education is just beginning, the information gleaned from teacher and student interactions (when the activity is the learning of motor skills) is important to consider. For example, the work of Anderson (1975), Bookhout (1967), Cheffers, Amidon, and Rodgers (1974), Nygaard (1975), Smith (1971), and Siedentop and Hughley (1975) have contributed to the knowledge base for the study of recording and analyzing teacher behaviors in physical education and sports environments.

The purpose of this study is to contribute knowledge relative to more or less effective selective teacher behaviors as perceived by both students and teachers when the subject is tennis. Therefore, the research questions for the study center on the following.

1. What are the frequency of occurrences of selected teacher behaviors over the three teaching occasions in tennis courses as measured on the Physical Education Observation Instrument (PEOI)?
2. Is there a relationship between teacher and student perceptions of the effectiveness of selected instructional behaviors during the teaching of tennis?
3. Are there relationships in the selected behavior occurrences of more effective and less effective teachers as determined by students, based on the observations by raters using the PEOI?

## METHOD

Sample. Sixteen college instructors (8 males and 8 females) volunteered from the Physical Education Activities Program (PEAP) at the University of Illinois at Urbana-Champaign to participate with their classes in the study. There were 16 sections of beginning Tennis I classes taught 2 days per week, 1½ hours per day, during an 8-week session, for a total of 16 class days. Each teacher had a minimum of one year of teaching experience at the college level. Class size ranged from 15 to 23 students, and a total of 365 college students participated. Because of absenteeism and other uncontrollable factors, a total of 297 students were used in the final analysis. The student population was heterogeneous and all classes were coeducational with the following breakdowns.

TABLE 1

Student Participants by Sex and Year in College (N=297)

| | Freshmen | Sophomore | Junior | Senior | Graduate |
|---|---|---|---|---|---|
| Females | 31 | 38 | 35 | 35 | 8 |
| Males | 23 | 30 | 39 | 55 | 3 |

Instrumentation. The Physical Education Observation Instrument (PEOI) (Taylor 1976) was used on three occasions to rate the frequency of occurrences of selected teacher and student behaviors (see Appendix). The PEOI includes 14 behavior variables: 9 are teacher behaviors, 4 are student behaviors and the final variable, "other," is a catch-all category for all behavior observed but not mentioned in the instrument. Teacher behaviors selected for the PEOI were deduced from physical education literature and research. Student behaviors were modified from Jewett's (1971) "Process Oriented Classification of Movement."

Student and teacher questionnaires were developed for this study (see Appendix). After numerous revisions, several pilot tests, and consultations with the Survey Research Laboratory (specialists in questionnaire design), a final version of the questionnaire was developed which contained corresponding questions on the teacher and student instruments that aligned in meaning with the teacher behaviors on the PEOI.

## PROCEDURE

Rater Training and Reliability Study. Six physical educators acted as raters in the study. All raters were familiar with tennis to the extent of taking a college tennis course and participating in tennis during their leisure time. The systematic training of raters occurred in ten hours in the following manner.

1. Raters learned the definitions of the PEOI behaviors.
2. Raters learned and practiced operating the PEOI.
3. Raters received practice in operating the PEOI while watching two videotapes of teachers (one male and one female) instruct coed college tennis classes.
4. Raters received practice in operating the PEOI during a live tennis class for a half-hour each.

Rater Reliability Study. In order to establish rater reliability using the PEOI in tennis classes, videotapes of two males and two females teaching college coed tennis classes were made. All teaching episodes were taped for 45 minutes to capture at least a half-hour of good instructional activity which best illustrated the variables on the PEOI.

For the inter-rater phase of the reliability study, the raters together observed and coded on the PEOI 15 minutes of each of the four videotaped teaching episodes, for a total of one hour. One week later, the intrarater phase was conducted with each rater individually observing and coding the same tapes.

Flander's Method of Calculating for Optimal and Minimal Cases (Frick and Semmel 1974, 1978) and the Pearson Product Moment Correlation were employed for inter- and intrarater analyses. Inter-rater scores ranged from .86 to .99 and intrarater scores ranged from .72 to .95 for all raters. These scores indicate that the raters were able to reliably and objectively operate the PEOI; therefore, they were ready to proceed with the observations in the PEAP study.

_Tennis Settings_. The observations of the 16 teachers by 6 raters occurred during the _second_, _fourth_ and _seventh_ weeks of the instructional sessions. Raters coded for a half-hour, beginning 15 minutes after the scheduled starting time of the class. Two raters were assigned to 2 classes and 4 raters were assigned to 3 classes. All raters observed each of their assigned classes on 3 occasions. During the eighth week of instruction, teachers and their classes were requested to complete the postactivity questionnaire developed by the investigators.

## RESULTS

The results of the study will be presented by addressing each research question.

1. _What were the frequency of occurrences of selected teacher behaviors over three teaching occasions in tennis courses as measured on the PEOI?_ The information decoded from the PEOI provides us with descriptions of different

frequency totals of teachers' use of selected behaviors over three observation occasions as shown in Figure 1. Table 2 provides the means and standard deviations of the frequency counts and indicates how teachers varied in their exertion of those behaviors over three instructional occasions.

As we consider each occasion, we see the apparent differences. The first occasion illustrates that certain behaviors were utilized more than others. This can be explained because the courses were in their second week, which possibly means that instruction was geared to the presentations and practice of fundamental tennis skills that involved more teacher and student direct interaction.

TABLE 2

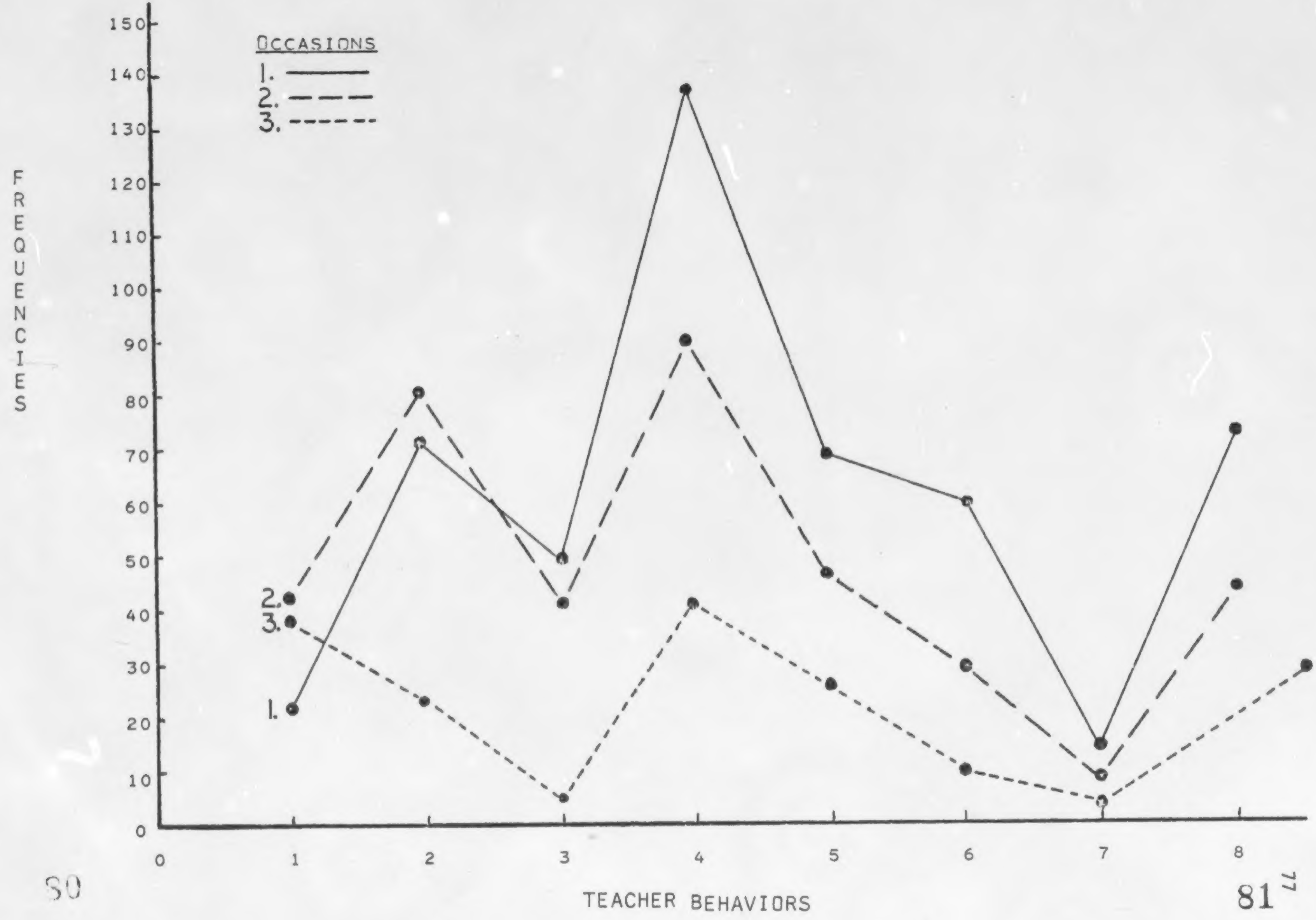
Frequency of Occurrences of Selected Teacher Behaviors Over Three Occasions

| | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD |
| Managerial | 21.8 | 17.1 | 42.88 | 58.0 | 40.06 | 61.9 |
| Explanation | 69.6 | 37.4 | 75.7 | 45.5 | 22.7 | 46.9 |
| Demonstration | 48.8 | 23.3 | 36.0 | 33.6 | 6.9 | 14.6 |
| Drill and Practice | 135.7 | 145.5 | 86.9 | 68.8 | 38.6 | 71.7 |
| Reflective Engagement | 68.3 | 36.9 | 44.7 | 44.2 | 28.6 | 53.9 |
| Feedback | 57.1 | 36.0 | 31.1 | 30.0 | 12.0 | 31.7 |
| Reinformcement | 15.2 | 10.2 | 12.0 | 15.6 | 2.8 | 6.4 |
| Individualized Instruction | 72.5 | 36.5 | 49.03 | (48.9) | 31.2 | 59.2 |

Direct interaction implies that the teacher is following, in most instances, a planned instructional procedures basically portrayed through several variables on the PEOI. Therefore, among the variables used, promoting drill and practice

Figure 1.

PEOI AVERAGE TEACHER BEHAVIOR FREQUENCIES (N=16) OVER THREE OCCASIONS



(mean score 135.7) was the dominant behavior accompanied closely by teacher individualized instruction (72.5), explanation (69.6) and reflective engagement (68.3). These behaviors form a pattern in which promoting drill and practice appears to be a structuring action, that is, as a direct teacher act which allows students to practice the fundamentals of the activity from which come teachers' intervention behaviors such as individualized instruction, explanation and reflective engagement. It is important to note that the activities of the teacher are recorded from the perspective of instructional direction to a group and that the only measure of attention to an individual is recorded in the individualized instruction variable. Although this is helpful, we are not necessarily concerned at this time with which students receive what amount of individualized instruction from the teacher. At this point, we only presume a distribution of individualized attention to class members.

The second observation occasion occurred during the fourth week of instruction and depicts teacher behavior occurrences with close mean score frequency ranges. The pattern of behaviors is very similar to that of the second week of instructions: promoting drill and practice, explanation and reflective engagement being the dominant behaviors, although there was a decline in the time spent in promoting drill and practice and in individualized instruction.

During the seventh week (the third observation period), the pattern of behaviors is similar to the patterns of the first and second occasions, except for a decline in the third session of all frequencies of behaviors but managerial engagement. It is interesting to note and difficult to explain the decline in feedback over the three occasions. Little time is spent over the three observational occasions on reinforcement, with a decline over time of individualized instruction.

2. Is there a relationship between teacher and student perceptions of the effectiveness of selected instructional behaviors during the teaching of tennis? During the final week of classes, students and teachers were asked to complete the post-activity questionnaire which provided their perceptions of teachers' use of the selected behavior as the behaviors contributed to student's learning of tennis. As mentioned before, the items on the teacher and student questionnaire correspond to and align with the variables on the PEOI.

After correlating the average score on each corresponding teacher and student item within classes and for each class, the results indicate a significant inverse relationship between two of the eight variables. Teacher management (r=-.64) and demonstration (r=-.41) had negative correlations indicating the inaccuracy of teacher and student perceptions on these variables.

The other variables ranged from .01 to -.20, indicating no relationship between what teachers believed they did in the course and what their students perceived as occurring in the course. We can only conclude at this time that no relationship exists between teacher self-report and student report of occurrences of selected behaviors during teaching which affected student learning.

3. Are there differences and/or similarities in behavior occurrences of more effective and less effective teachers as determined by students, based on the observation by raters using the PEOI? The student rating of teachers were divided into three groups: those that had the highest rating by their students on the post-activity questionnaire, with the majority of average item scores ranging from 4.0 to 3.5; those who had average item scores by their students of 3.4 to 2.9; and those teachers whose average ratings were 2.8 to 1.0. Of the 16 teachers, 4 were high, 8 were average, and 4 were low. We then took the high and low teachers' averaged observation scores and compared them on each occasion.

Figures 2, 3, and 4 illustrate the behavior frequencies over occasions and identify the teachers with high scores as more effective and the teachers with low scores as least effective.

Occasion 1. Table 1 illustrates that the more and less effective teachers were very similar in their use of behaviors. This can be expected, given that during the second week of a beginning tennis class, teachers may still be providing students with fundamental skills; thus drill and practice is a predominant teacher and student act.

Occasion 2. Figure 3 indicates that the more and less effective teachers varied in their use of certain behaviors and that the variance can be easily identified in the indirect teacher dimensions. The difference tell us that the more effective teachers encouraged their class through the use of more reinforcement and individualized instruction than the less effective teachers in the indirect dimension. Also, more effective teachers used reflective engagement far less often than the other teachers, so we assume they were using teaching time more efficiently.

Occasion 3. Teachers in the two categories of effectiveness varied considerably in the direct and indirect dimension categories on all behaviors except reflective engagement. With the direct behaviors, more effective teachers spent far less time than did less effective teachers. What other behaviors are exerted by teachers? More effective teachers spent more time providing feedback, reinforcement and individualized instruction. A look at the less effective teachers tells us that they spent a good deal of time with the variables of managerial engagement, explanation and demonstration and promoting teacher dimensions, and the more effective teachers concentrated their efforts in the indirect teacher demensions.

Figure 2. OCCASION I

PEOI TEACHER BEHAVIOR FREQUENCIES AVERAGED OVER SELECTED TEACHERS

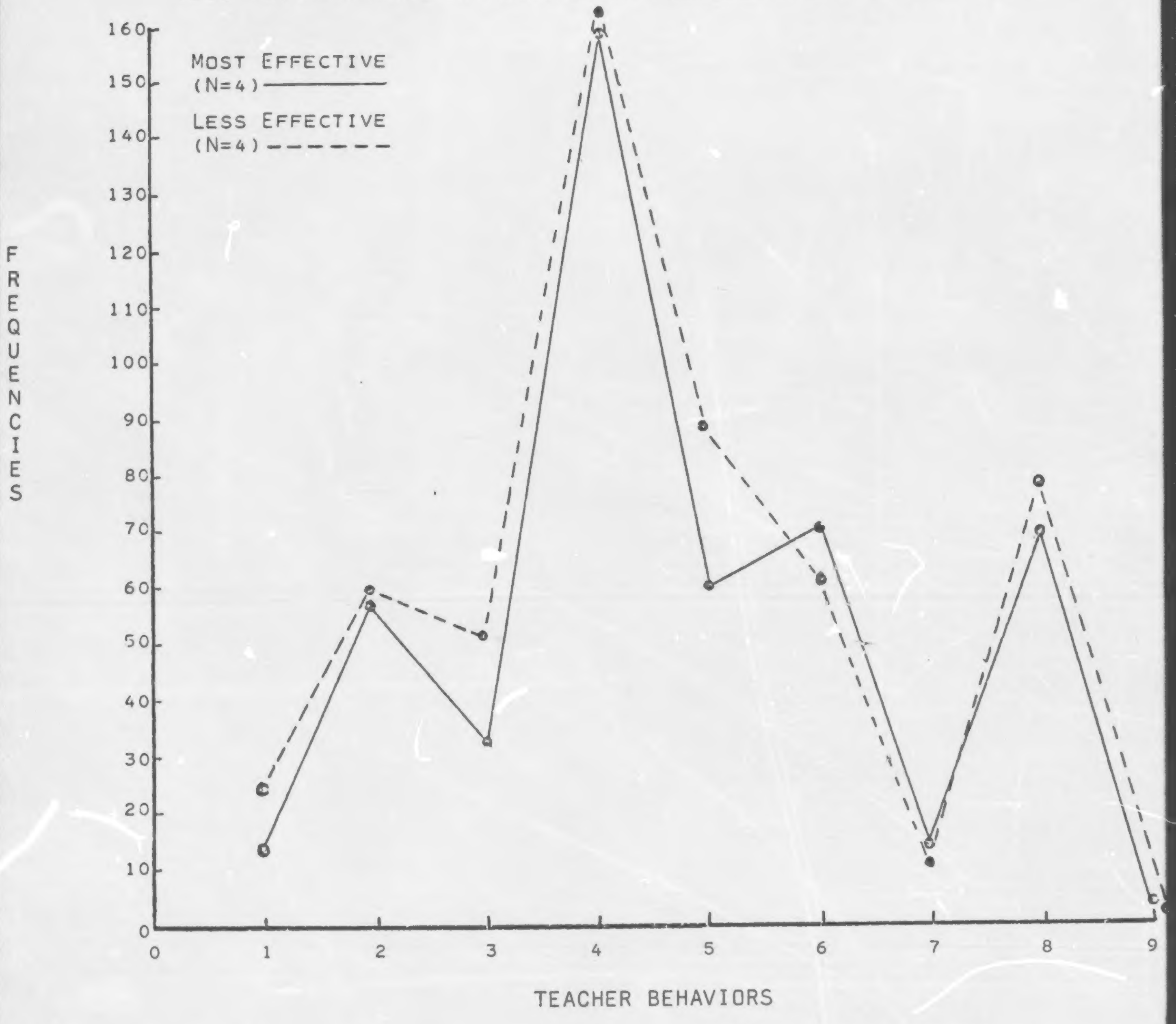


**Figure 3.** OCCASION II

PEOI TEACHER BEHAVIOR FREQUENCIES AVERAGED OVER SELECTED TEACHERS

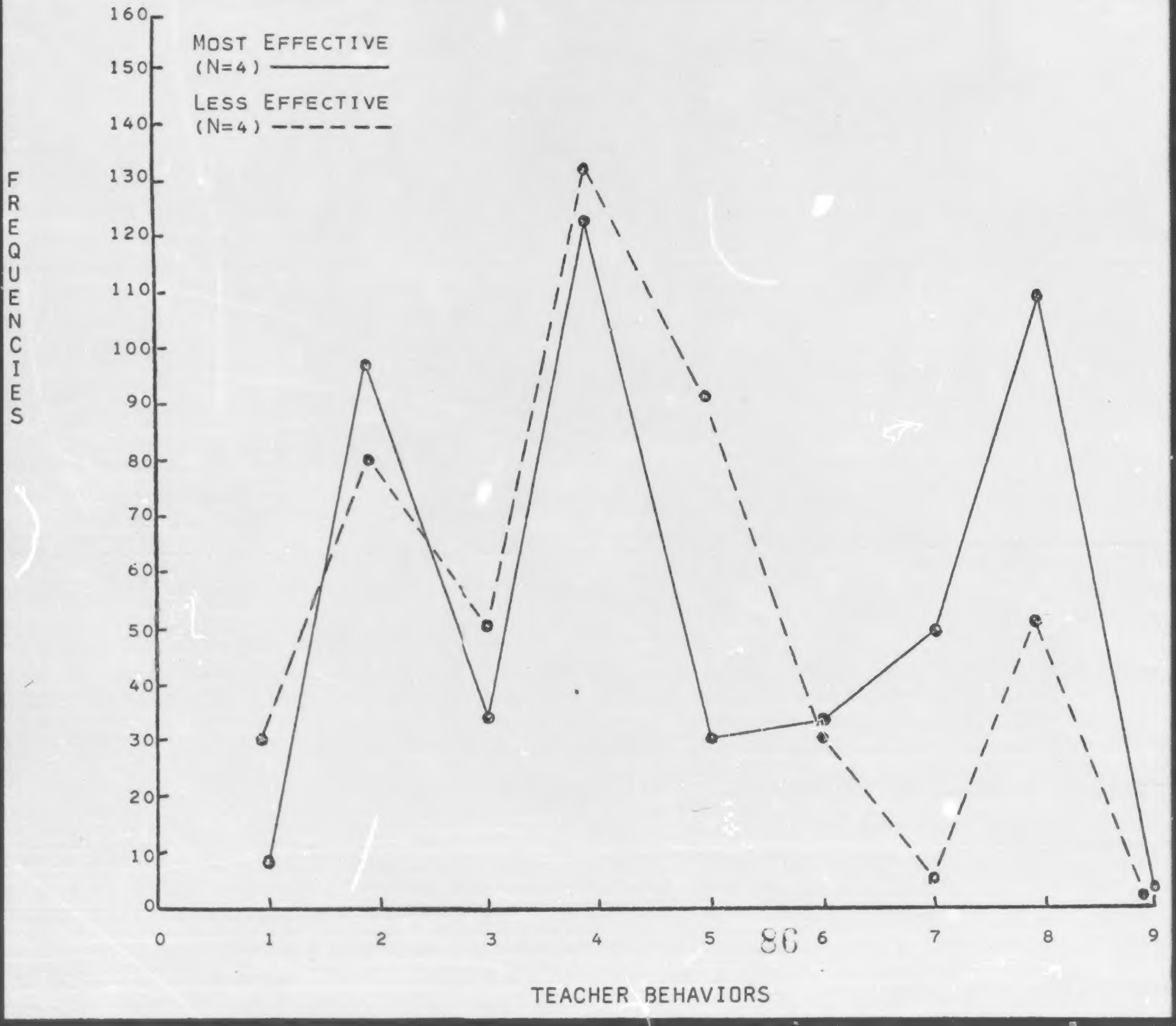
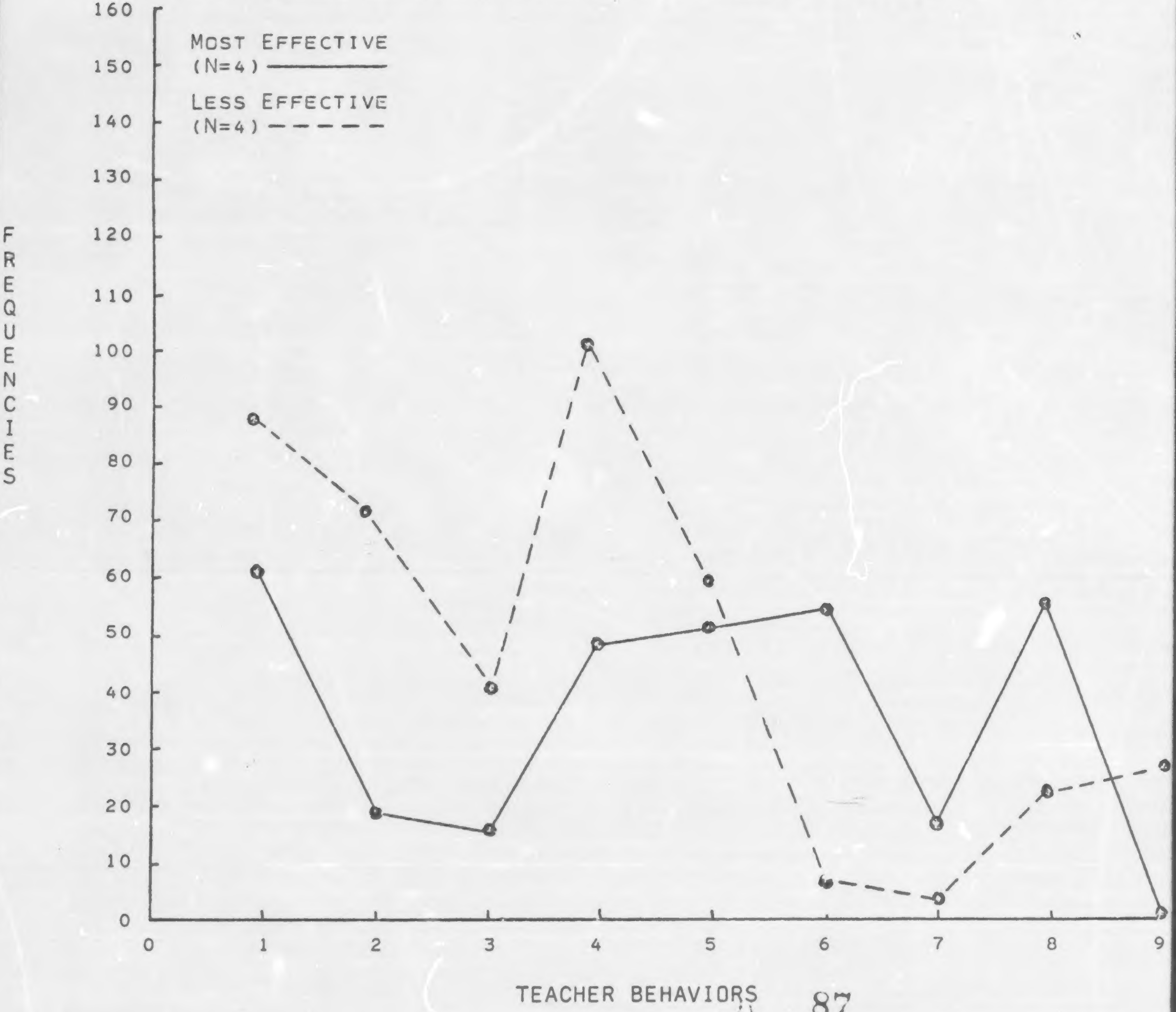


Figure 4. OCCASION III

PEOI TEACHER BEHAVIOR FREQUENCIES AVERAGED OVER SELECTED TEACHERS



## SUMMARY

In summary, some of our results are very important, but we have also come up empty-handed in a few areas. Overall, we cannot provide any conclusive evidence to substantiate the value of further research on student and teacher perceptions of teacher instructional behavior. However, the utilization of student ratings of teachers and the coding of teachers' behaviors by observers provides us with adequate information about what we consider to be the behaviors of more and less effective teachers while teaching tennis.

Our most disappointing result is that there is no significant correlation between teacher and student perceptions of the teachers' use of selected teacher behaviors. Teacher' self-reports were the greatest negative factor in this portion of the study. It appears that teachers' perception of their own performance of selected behaviors are substantially lower than students' perception of teachers' performances of selected behaviors. It is difficult to explain this result. Therefore, our conclusions follow those suggested by Hook and Rosenshine (1979: 10): "If a teacher answers a questionnaire on a variety of specific activities, we cannot assume that these reports correspond to actual practice." We concur with this statement because what raters coded and what students rated differed from what teachers had on their questionnaires in regard to actual practice in this study.

We are fairly well satisfied with our information generated from separating teachers who were rated high by their students (4.0 to 3.5) and those rated low by their students (2.8 to 1.0). This descriptive information was then compared to observers' frequency counts of behaviors for the two groups (four teachers in each group). Essentially, we see that as the eight-week course progressed, teacher behaviors of the two groups changed, particularly in the indirect behavior category. Thus, we are able to identify the more effective and less effective teacher behaviors. Of course, many more studies in tennis would have to be conducted before we could state what behaviors should be exerted at what time in order to provide students with the best possible learning outcomes. It is interesting to note that the more effective teachers were older, more experienced and rated highly in the subjective departmental teacher evaluations compared to the less effective teachers, who had little experience, were younger and rated lower on the subjective departmental teacher evaluation.

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# APPENDIX

## THE PHYSICAL EDUCATION OBSERVATION INSTRUMENT
## TEACHER AND STUDENT BEHAVIORS

| | | |
|---|---|---|
| DIRECT TEACHER INFLUENCE | 1. | Managerial Engagement: |
| | | 1.1 Administering |
| | | 1.2 Directing |
| | 2. | Explanation: |
| | | 2.1 Defining |
| | | 2.2 Constructing |
| | 3. | Demonstration: |
| | | 3.1 Presenting |
| | | 3.2 Analyzing |
| | 4. | Drill and Practice on Basic Skill Task: |
| | | 4.1 Rehearsing |
| | | 4.2 Emphasizing |
| | 5. | Reflective Engagement: |
| | | 5.1 Considering |
| | | 5.2 Deliberating |
| INDIRECT TEACHER INFLUENCE | 6. | Feedback: |
| | | 6.1 Informing |
| | | 6.2 Correcting |
| | 7. | Reinforcement: |
| | | 7.1 Praising |
| | | 7.2 Rewarding |
| | 8. | Individualization: |
| | | 8.1 Assisting |
| | 9. | Disengagement |
| STUDENT ENGAGEMENT | 10. | Developmental Engagement: |
| | | 10.1 Listening |
| | | 10.2 Watching |
| | | 10.3 Questioning |
| | | 10.4 Perceiving |
| | 11. | Organizing Movement: |
| | | 11.1 Imitating |
| | | 11.2 Patterning |
| | | 11.3 Adapting |
| | 12. | Creative Movement Engagement: |
| | | 12.1 Playing |
| | 13. | Disengagement |
| | | 13.2 Disruptive Behavior |
| OTHER | 14. | Behaviors Not Identified by Above Behaviors |

## TEACHER PERCEPTIONS

Please indicate how you feel about the following statements by circling one answer for each question. (SA-Strongly Agree; A-Agree; D-Disagree; SD-Strongly Disagree; F-Frequently; S-Sometimes; S-Seldom; N-Never)

Age ________ Sex ________ Course Taught ________________________

| | | | | | |
|---|---|---|---|---|---|
| 1. | Demonstration of techniques provided the students a picture of tennis skill requirements. | SA | A | D | SD |
| 2. | Students were provided with verbal reinforcement about their performance. | F | S | S | N |
| 3. | Daily assigning of partners and instructional areas required very little time. | SA | A | D | SD |
| 4. | As much individualized instruction was given as time permitted. | SA | A | D | SD |
| 5. | Little class time was spent taking attendance. | SA | A | D | SD |
| 6. | I think student expectations about learning tennis were fulfilled in this class. | SA | A | D | SD |
| 7. | Students who needed the most assistance got special attention. | SA | A | D | SD |
| 8. | Practice time in this course was sufficient for the student to learn how to perform the skill. | SA | A | D | SD |
| 9. | Students obtained one-to-one instruction when they were having difficulties with tennis techniques. | SA | A | D | SD |
| 10. | Information about tennis techniques to be practiced was clearly presented for each lesson. | F | S | S | N |
| 11. | Objectives and goals for daily class performance provided the students incentive to practice. | SA | A | D | SD |
| 12. | Students had ample time to drill on tennis techniques. | SA | A | D | SD |
| 13. | From time to time student tennis skills were analyzed and constructive suggestions for improvement were given. | F | S | S | N |
| 14. | Students' performances were closely observed. | SA | A | D | SD |
| 15. | Negative criticism of students' tennis performance was avoided. | SA | A | D | SD |
| 16. | Students were praised when their performance deserved a compliment. | F | S | S | N |
| 17. | Tennis techniques were demonstrated to students when they were having difficulties performing. | F | S | S | N |
| 18. | When I noticed a student incorrectly performing a tennis technique, I immediately informed the student of the correct technique. | F | S | S | N |
| 19. | Non-verbal praise was given to students for their good performance. | SA | A | D | SD |

## STUDENT PERCEPTIONS

Please evaluate your tennis instructor's teaching by circling one answer for each question. (SA-Strongly Agree; A-Agree; D-Disagree; SD-Strongly Disagree; F-Frequently; S-Sometimes; S-Seldom; N-Never)

Age _____ Sex _____ Year in School ____________ Class: Tennis I ________ Tennis II ________

| | | | | | |
|---|---|---|---|---|---|
| 1. | My expectations about learning tennis were fulfilled in this class. | SA | A | D | SD |
| 2. | My tennis skills were constructively analyzed by the teacher. | F | S | S | N |
| 3. | My instructor was a knowledgeable tennis teacher. | SA | A | D | SD |
| 4. | The objectives and goals about tennis play as stated by the provided incentive for me to practice. | SA | A | D | SD |
| 5. | The teacher worked with me on a one-to-one basis when I had difficulty with a technique. | SA | A | D | SD |
| 6. | The teacher's comments about my tennis technique encouraged me to perform better. | SA | A | D | SD |
| 7. | Upon completion of a good performance, I could tell when the teacher was pleased even if he/she didn't say one word. | F | S | S | N |
| 8. | The teacher provided specific information about tennis techniques to be performed during class time. | F | S | S | N |
| 9. | The teacher closely observed my tennis performance. | F | S | S | N |
| 10. | I was provided sufficient time to practice tennis techniques to learn how to perform the skill. | F | S | S | N |
| 11. | I was provided ample time to drill on tennis techniques. | F | S | S | N |
| 12. | Teacher praise of my tennis performance was rewarding. | SA | A | D | SD |
| 13. | The teacher demonstrated a tennis technique whenever I needed to see how it should be done. | SA | A | D | SD |
| 14. | When I had a problem with technique, the teacher analyzed my difficulty and demonstrated the correct skill performance. | F | S | S | N |
| 15. | The teacher spent very little time taking daily class attendance. | SA | A | D | SD |
| 16. | I performed in this class without receiving attention from the teacher. | F | S | S | N |
| 17. | I would have liked the teacher to have provided more personalized attention when I was having problems. | SA | A | D | SD |
| 18. | The teacher avoided negative criticism of my tennis performance. | SA | A | D | SD |
| 19. | On a daily class basis, very little time was wasted on assigning me a tennis court and a partner for instruction. | SA | A | D | SD |
| 20. | When my tennis technique was incorrect, the teacher immediately informed me how to use the correct technique. | SA | A | D | SD |

PHYSICAL EDUCATION OBSERVATION INSTRUMENT (PEOI)

| Intervals | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Managerial Engagement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Explanation | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Demonstration | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Promoting Drill & Practice on Basic Skill Task | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reflective Engagement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Feedback | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Reinforcement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Individual Instruction | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Disengagement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Developmental Engagement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Organizing Movement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Creative Movement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Disengagement | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| TOTAL | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

# DOUBLES PLAY STRATEGIES IN RACQUETBALL ON PLATO*

by

J. W. Kent
P. A. Bayalis
UD PLATO
Department of Physical Education
University of Delaware
Newark, DE

## Abstract

The purpose of this presentation is to introduce PLATO as a teaching tool to assist students in the acquisition of cognitive skills for successful doubles play in racquetball. Doubles play for the beginning-level racquetball player can be a very hazardous activity. Safety for the players is an important consideration and subsequently much time is given to stroke development and refinement in singles rather than doubles play. To facilitate the learning of doubles play strategies, the use of computer-assisted instruction and the development of appropriate materials would greatly enhance the opportunity for learning while not creating the risk of injury. PLATO (Programmed Logic for Automatic Teaching Operations) is a computer-assisted instructional system that allows for unique individual interaction with the special features of a plasma panel screen. The lesson presented will give a brief introduction to court markings, rules of service order, and strategies of play to be employed by the service side and the receiving side. Conference attendees will be given an opportunity to use the PLATO terminals and to experience the lession for strategy and other cognitive skills for doubles play in racquetball.

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The game of doubles in racquetball can be a challenging activity, a fun-filled social activity, a hazardous activity depending upon the skill level of the players or, like a multiple choice question, it can be all of the above. Teaching doubles play in beginning racquetball classes at the University of Delaware does not receive a great deal of emphasis because of the safety factor involved in having novice players with uncontrolled stroke techniques in a confined space with no concept of the location of the other players in the court.

The purpose of this project is to develop a package of information on PLATO to facilitate the learning of doubles play while class and court time are used for the development of proper stroke techniques and the strategy of singles play. (PLATO is a computer assisted instructional system that allows each individual student to interact with the computer and the special features of a plasma panel screen.)

The success of PLATO as a teaching tool has been demonstrated in several disciplines (for music, see Hofstetter 1975; for foreign language, see Culley 1980; for math, see Poor, Qualls, and Brown 1979). Barlow, Markham, and Richards (1979) report that students using PLATO for laboratory projects in physical education show a better grasp of material and receive better project grades than do students not using it. In addition, the time the students spend working with PLATO is significantly less than the time necessary for project completion by the nonusers. The sports skill of volleyball is currently undergoing evaluation (see Delaware PLATO Project 1978) to determine if the learning of cognitive skills in a sports activity will be enhanced by the use of computer-assisted instruction. The lesson on racquetball, presented at this conference on Friday, June 13, will be evaluated during the 1980-81 academic year.

The concern for safety is well documented by Della-Giustina (1980), who points out the risk of injury to the eye and the area around the eye. Providing a safe learning environment for a potentially hazardous activity is a major goal of racquetball and PLATO.

The student needs only a minimal amount of knowledge to interact with the system. Basic reading skills and a fumbling acquaintance with a typewriter keyboard are all that is necessary. When the student sits down at the terminal, he is greeted by the "Welcome to PLATO" page (also referred to as the sign-on page). The student types in his name, follows directions, and then on page two is asked to identify his user group name. These activities are usually identified on a handout which is prepared and distributed to the students during a brief orientation to the terminal. Once these tasks are completed, the name of the lesson to be studied (in this case, "Doubles Racquetball") is presented to the student. The student then responds to whatever questions are put to him by typing an answer, a letter, or a number, or by touching the plasma panel screen. The questions may focus on the situations of play represented by the animation capabilities of PLATO. The animations may preclude the student's activity at the terminal or the student may be asked to position a given strategy prior to the animation process; the system has the flexibility to perform either way.

The lesson on offensive positions includes a quiz on the markings of the court and a review of the court markings. This portion of the lesson should be an easy review of singles play. The remaining information in the lesson discusses the positioning and strategy for doubles play using the strategies of side-by-side alignment, front-and-back and diagonal positioning. The lesson is concluded with a quiz on offensive positions and the questions are called up on the screen in a random order so that memorization of order of responses will not be possible. It is anticipated that the self-paced learning afforded by PLATO for doubles play strategies in racquetball will increase cognitive learnings about the game and make doubles play more challenging and more sociable, while enabling teachers to better meet their obligations of presenting total information about an activity to their classes.

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# COMPONENTS OF TENNIS-PLAYING ABILITY FOR THE BEGINNING-LEVEL PLAYER

by

Larry D. Hensley
B. East Whitfield
University of Northern Iowa
Cedar Falls, IA

## Abstract

The purpose of this study is to psychometrically identify the specific skills underlying the tennis-playing ability of beginning-level players. No attempt is made to identify or control the general motor abilities (e.g., speed, agility, strength, or movement time) that facilitate the execution of the various skills required in tennis, although it is recognized that these are integral components of any movement skill. A battery of 14 tennis skill tests selected to represent the domain of tennis playing was administered to 80 students enrolled in beginning-level tennis at the University of Georgia. The data collected are analyzed by the following factor analytic models: alpha factor analysis, canonical factor analysis, and maximum-likelihood factor analysis. The results indicate that tennis instruction for novice players should be designed to teach the forehand and backhand concurrently. It is suggested that to maximize the efficient learning of tennis skills, instruction should focus on the fundamental temporal, spatial, and motion elements of hitting a tennis ball, rather than on breaking down the skills into specific forehand and backhand techniques.

Tennis in its simplest form, merely involves hitting a ball over a net. This is done, of course, within a specified area, using an implement called a racket. The addition of an opponent, boundary lines, and a prescribed set of rules make tennis one of the most popular sports in the world today. One of the crucial tasks facing educators and teachers of tennis has been the development of instructional strategies directed toward the constructs or underlying components of the domain of tennis-playing ability. Subjective opinions of numerous tennis experts generally support the idea that the forehand, backhand, serve, and volley are desirable skills to teach a beginner. The field of teaching and coaching tennis has become so sophisticated, however, that reliance solely on personal biases for the foundation of one's instructional program has extreme limitations.

The purpose of this study is to psychometrically identify the specific skills underlying the tennis-playing ability of beginning-level tennis players. The effective teaching of tennis skills and the assessment of their achievement is partially dependent upon the ability to accurately identify the critical components of the sport. Fourteen tennis skills tests (see Table 1), all purporting to measure a specific component of tennis-playing ability, were selected as test variables. The tests were selected with the following criteria in mind--

1. that the test can be reliably administered;
2. that the test purports to measure a specific component of tennis-playing ability;
3. that the test is administratively feasible;
4. that the test can be objectively administered;
5. that the test is accompanied by standardized directions for administration and scoring.

Table 1
Tennis Skill Tests

| | |
|---|---|
| Broer-Miller Forehand Drive Test | (1950) |
| Shephard's Forehand Drive Test | (1972) |
| Hewitt's Forehand Drive Test | (1966) |
| Timmer's Forehand Volley Test | (1965) [a] |
| Broer-Miller Backhand Drive Test | (1950) |
| Shephard's Backhand Drive Test | (1972) |
| Hewitt's Backhand Drive Test | (1966) |
| Timmer's Backhand Volley Test | (1965) [a] |
| Scott-French Backboard Tennis Test | (1959) |
| Kemp-Vincent Rally Test | (1968) |
| Hewitt's Service Placement Test | (1966) |
| Hewitt's Speed of Service Test | (1966) |
| Cobane Test for Service | (1962) |
| DiGennaro Service Test | (1969) |

[a] Modified for purposes of study

Based upon the test variables selected, a logical hypothesis of the underlying factor structure of tennis skills might include (1) forehand strokes, (2) backhand strokes, and (3) overhead strokes. No attempt was made to identify or control the general motor abilities (e.g., speed, agility, strength, or reaction time) that facilitate the execution of the various skills required in tennis, although it is recognized that these are integral components of any sport skill.

The 14 skills tests were administered to 80 students, 36 males and 44 females, in a beginning tennis class at the university level. The intercorrelations of the scores for the 14 tests are presented in Table 2. The intercorrelation coefficients range from .229 to .844, all significantly different from zero at or beyond the .05 level. The magnitude of the correlations indicate that a substantial amount of variance is shared by the variables, thus suggesting

## Table 2

Intercorrelations of the 14 Tests

| | Tests | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | Broer-Miller Forehand Drive | 1.000 | | | | | | | | | | | | | |
| 2. | Broer-Miller Backhand Drive | .541 | 1.000 | | | | | | | | | | | | |
| 3. | Shephard's Forehand Drive | .621 | .627 | 1.000 | | | | | | | | | | | |
| 4. | Shephard's Backhand Drive | .608 | .591 | .622 | 1.000 | | | | | | | | | | |
| 5. | Cobane Test for Service | .572 | .552 | .570 | .678 | 1.000 | | | | | | | | | |
| 6. | Hewitt's Forehand Drive | .419 | .419 | .551 | .434 | .334 | 1.000 | | | | | | | | |
| 7. | Hewitt's Backhand Drive | .557 | .604 | .540 | .615 | .480 | .467 | 1.000 | | | | | | | |
| 8. | Timmer Forehand Volley | .318 | .336 | .369 | .412 | .518 | .229 | .284 | 1.000 | | | | | | |
| 9. | Timmer Backhand Volley | .412 | .434 | .392 | .590 | .490 | .313 | .425 | .512 | 1.000 | | | | | |
| 10. | Hewitt's Service Placement Test | .453 | .467 | .382 | .511 | .631 | .237 | .435 | .432 | .462 | 1.000 | | | | |
| 11. | Hewitt's Speed of Service Test | .477 | .578 | .443 | .523 | .707 | .353 | .451 | .427 | .428 | .844 | 1.000 | | | |
| 12. | DiGennaro Service Test | .509 | .534 | .506 | .594 | .639 | .406 | .415 | .536 | .494 | .506 | .542 | 1.000 | | |
| 13. | Kemp-Vincent Rally Test | .611 | .666 | .617 | .581 | .615 | .337 | .487 | .307 | .466 | .493 | .581 | .576 | 1.000 | |
| 14. | Scott-French Backboard Test | .666 | .618 | .637 | .621 | .729 | .475 | .565 | .378 | .507 | .520 | .627 | .597 | .741 | 1.000 |

that a number of underlying factors are present. In order to determine the basic dimensions of the data, a principal components analysis was performed prior to proceeding with the factor analyses. Application of the Screen Test (Figure 1) to the eigenvalue-eigenvector decomposition of the correlation matrix suggests that three components should be retained. The data collected were then analyzed by the following factor analytic models: alpha factor analysis and canonical factor analysis. Both orthogonal and oblique rotations were performed with each of these analyses.

For purposes of simplification in presenting the various factor matrices, the specific tennis skills tests are referred to as Test 1, Test 2, and so on. The name of each test and its corresponding number is presented in Table 3.

Table 3

Identification of Tests

| Tests | Test Number |
|---|---|
| Broer-Miller Forehand Drive | 1 |
| Broer-Miller Backhand Drive | 2 |
| Shephard's Forehand Drive | 3 |
| Shephard's Backhand Drive | 4 |
| Cobane Test for Service | 5 |
| Hewitt's Forehand Drive | 6 |
| Hewitt's Backhand Drive | 7 |
| Timmer Forehand Volley [1] | 8 |
| Timmer Backhand Volley [2] | 9 |
| Hewitt's Service Placement Test | 10 |
| Hewitt's Speed of Service Test | 11 |
| DiGennaro Service Test | 12 |
| Kemp-Vincent Rally Test | 13 |
| Scott-French Backboard Test | 14 |

[1] Modification of Timmer's Forehand Drive Test

[2] Modification of Timmer's Backhand Drive Test

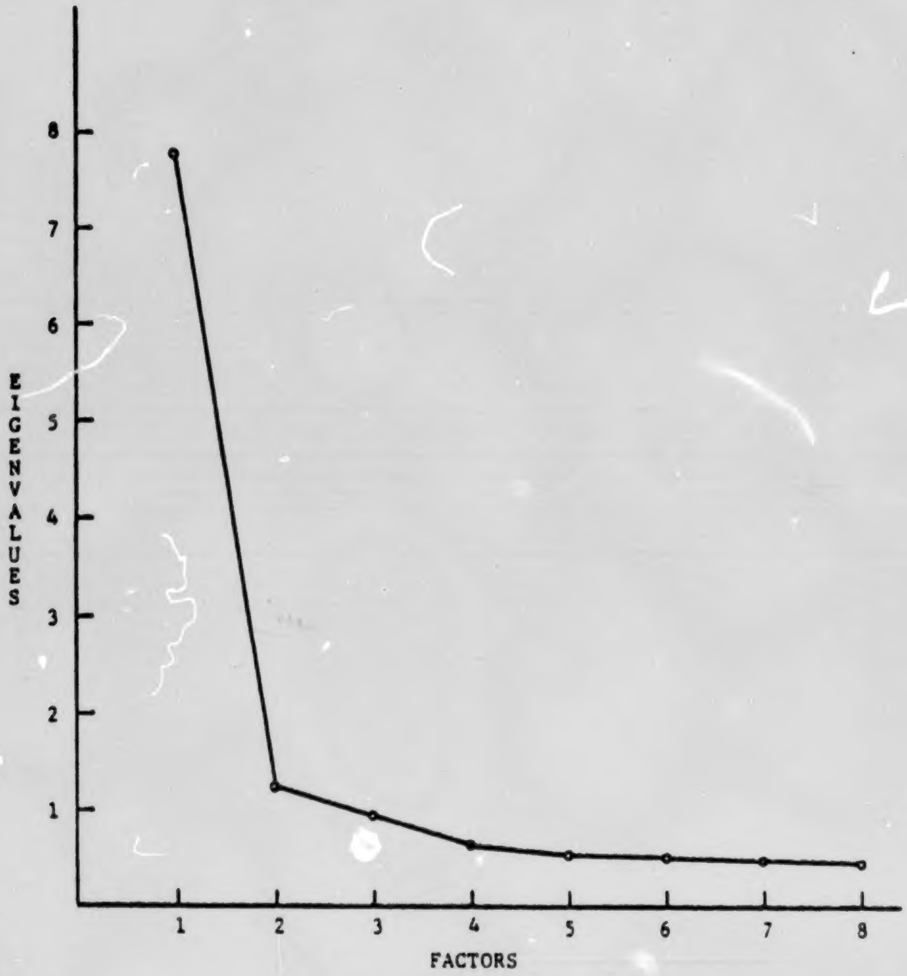

Figure 1. Scree Test

The factor analyses of the data collected for the selected tennis skill tests identify three components of beginning-level tennis-playing ability that are robust across models: (1) ground strokes; (2) serving; and (3) volleying. The significant factor loadings for the rotated factor matrices and communality estimates for each analysis are presented in Table 4 and 5.

The major implication of these findings is that tennis instruction for beginning-level players should be designed to teach the forehand and backhand strokes concurrently. The hypothesized factors of a forehand and a backhand stroke did not develop as distinct factors. This idea seems to raise questions regarding the traditional method of teaching tennis in which the beginning-level player first learns to hit a forehand stroke, then upon achieving a certain skill level he/she progresses to the backhand stroke. Rather than focusing instructional strategies on the forehand, backhand, volley, and serve, it is suggested that a broader approach be taken, one that emphasizes the fundamental temporal, spatial, and motion elements of hitting a tennis ball. Based on the results of this study, these elements might be characterized as follows:

1. hitting an approaching ball after it has bounced--ground strokes;
2. hitting an approaching ball before it has bounced--volley;
3. hitting a ball from a self-toss--serve.

## Table 4

## Significant Factor Loadings and Communalities for Alpha Factor Analysis

| Tests | Orthogonal Rotated Factors |  |  | Oblique Rotated Factors |  |  | $h^2$ |
|---|---|---|---|---|---|---|---|
|  | 1 | 2 | 3 | 1 | 2 | 3 |  |
| 1 | .663 |  |  | .695 |  |  | .574 |
| 2 | .653 | .363 |  | .665 |  |  | .604 |
| 3 | .776 |  |  | .866 |  |  | .680 |
| 4 | .626 |  | .441 | .579 |  |  | .673 |
| 5 | .449 | .565 | .432 |  | .433 |  | .708 |
| 6 | .572 |  |  | .650 |  |  | .364 |
| 7 | .654 |  |  | .701 |  |  | .524 |
| 8 |  |  | .734 |  |  | .812 | .601 |
| 9 |  |  | .611 |  |  | .606 | .541 |
| 10 |  | .760 |  |  | .773 |  | .729 |
| 11 |  | .834 |  |  | .852 |  | .851 |
| 12 | .455 | .367 | .512 |  |  | .418 | .605 |
| 13 | .611 | .453 |  | .594 |  |  | .615 |
| 14 | .680 | .444 |  | .666 |  |  | .720 |

## Table 5

## Significant Factor Loadings and Communalities for Canonical Factor Analysis[1]

| Tests | Orthogonal Rotated Factors 1 | Orthogonal Rotated Factors 2 | Orthogonal Rotated Factors 3 | Oblique Rotated Factors 1 | Oblique Rotated Factors 2 | Oblique Rotated Factors 3 | $h^2$ |
|---|---|---|---|---|---|---|---|
| 1 | .677 | | | .732 | | | .611 |
| 2 | .653 | .366 | | .683 | | | .626 |
| 3 | .747 | | | .838 | | | .652 |
| 4 | .603 | | .479 | .558 | | | .677 |
| 5 | .461 | .561 | .434 | | .394 | | .701 |
| 6 | .560 | | | .638 | | | .414 |
| 7 | .627 | | | .673 | | | .552 |
| 8 | | | .683 | | | .761 | .546 |
| 9 | | | .613 | | | .618 | .558 |
| 10 | | .777 | | | .776 | | .673 |
| 11 | | .795 | | | .779 | | .711 |
| 12 | .431 | .377 | .544 | | | .468 | .637 |
| 13 | .658 | .429 | | .686 | | | .653 |
| 14 | .676 | .444 | | .682 | | | .701 |

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[1] All negative signs have been inflected to indicate an absolute relationship.

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# SPORTS PSYCHOLOGY

# ANTICIPATION IN JUNIOR TENNIS PLAYERS

by

L. J. Day
School of Physical Education
Adelaide College of the Arts and Education
46-68 Kintore Avenue
Adelaide
South Australia, 5000

## Abstract

Anticipation in this study refers to early prediction of outcome based on movement cues received from a hitter up to the point of contact with the ball. Male (n=11) and female (n=10) tennis players, 12-16 years of age, from a state junior training squad were tested: (1) on court, using a visor apparatus activated by a pressure switch on the hitter's racquet to obscure vision up to point of contact with the ball, and (2) viewing film clips of the hitter with the sequence of each shot only continuing to the contact point. In each case, subjects had to predict on a score sheet where the ball would land. They then underwent a ten-week training program during which they viewed sets of film clips similar to those used in initial test. They were given feedback of results and instructed as to what cues to look for. At the end of the ten weeks they were retested under both conditions. Results indicate that: (1) lateral prediction is very accurate and errors are equally distributed to either side of the actual landing point; (2) there is a consistent tendency to overestimate depth; (3) following the training, subjects show a significant improvement in both lateral and depth prediction ($p < .01$) on the film test; and (4) although some improvement occurs on the court test, it is not significant. The results are discussed in terms of practical implications.

Anticipation is extremely important in tennis, particularly at advanced levels of play. In fact, the size of the court and the speed of the shots hit by the opponent often mean that, unless the flight path is anticipated early enough, efforts to reach the ball to play a shot will be in vain. Anticipation also creates time for a player: it gives him a greater opportunity to position himself so that shots can be played from a balanced position in a mechanically effective manner; and it also provides the opportunity to utilize more strategy alternatives since there is more time to calculate the options, e.g., the player is not forced into defensive strokemaking by being out of position to play particular shots.

In a tennis game, anticipation is generally based on information from three sources: knowledge of an opponent's game; the cues he emits in deciding which stroke will be employed, right up to actually hitting the ball; and the flight path of the ball as it travels towards you. Whiting, Alderson and Sanderson (1973) and Whiting and Sharp (1974a, 1974b) have examined the strategies used in predicting the flight path of an approaching ball. This study examines anticipation based on the cues provided by an opponent as he plays a shot. It therefore includes such things as angle of the racquet face, arc of travel of the racquet head, and line of the shoulders and transfer of weight.

Jones (1974) claims success by using film in training his subjects to recognize these clues and therefore to anticipate more quickly. Haskings (1965), also using film, likewise concludes that anticipation is improved by training. However, in both of these investigations the criterion for improvement is time from impact on the opponent's racquet to subject's first movement in a direction which would result in intercepting the flight of the oncoming ball. This kind of measurement only allows for the possibility of a very crude perception and processing of cues--only enough to start to move in a direction which would probably intercept the flight path of the ball. The possibility of judging the speed of the ball, or its possible trajectory, is not accounted for.

In addition, Haskin's subjects could see the ball for up to eight feet after the hitter made contact with it, thereby blurring the distinction between anticipation due to monitoring the early flight path of the ball and anticipation due to monitoring movement cues of the opponent. Several investigators (see Alderson, Sully, and Sully 1974) have agreed that "gross orientation is probably started on the basis of perception of the ball's trajectory from a very early sample of flight information and is modified by a later sample." The design of the present experiment eliminated any monitoring of the ball's flight after impact; anticipation of where the ball would go was therefore based entirely on movement cues received from the opponent. To eliminate anticipation on the basis of strategy, as might occur in a normal rally during a game, only forehand shots were viewed and both the hitter and subject were placed on the center of the baseline at each end of the court.

Specifically, the study is a preliminary investigation to examine:

1. how accurately advanced junior tennis players could anticipate where a return would land on the basis of the opponent's movement leading up to the point of contact;
2. whether any pattern could be detected in such predictors; and
3. whether such prediction could be improved on the court by engaging in training sessions which used 16mm. film as the training medium.

## METHOD

Subject. Twenty-one male (n=11) and female (n=10) subjects between 12 and 16 years of age participated in the study. At the time, they were junior tennis players who had been specially selected on the basis of ability by the state hardcourt tennis association to undergo an intensive winter training course.

Procedures. Subjects were tested under two conditions, both before and after undergoing a ten-week training session in anticipation, using 16mm. film as the training medium. These test conditions were as follows.

1. Viewing a series of ten film clips of a peer performing the forehand drive, up to the point of contact with the ball. All of the subjects viewed the test film within a three-day period in the week prior to the first training session and again in the week immediately following the training period. All subjects were seated in the same position for each test and all were given identical instructions about test conditions and marking the scoring sheet. They were told that the ball need not land within the confines of the court, though no shot had been included which landed more than 0.5 m. outside of any line. The film was shown at 16 frames per second.

2. Viewing a player hitting forehand drives toward them on the court, vision being obscured at the moment of contact of ball with racquet. The hitter stood at the center of the base line and was aware of the fact that he had to play a forehand shot. No definite sequence was followed; in fact, the hitter was asked to hit the full range of forehand shots to any position on the singles court and to vary them randomly, the intent being to replicate the game situation and the criterion being improvement in anticipation as it applied to this situation.

Subjects remained outside of the gymnasium until called in for the test. They were then positioned centrally on the base line facing the hitter with a score sheet at elbow height in front of them. Following the fitting of the apparatus, they were given two practice trials to familiarize themselves with the equipment and the task. They were then given 10 good trials (ball to clear the net; if "out," to land within 0.5 m. of the singles court lines) and marked the score sheet immediately after the ball had been collected and all movement had stopped in the gymnasium.

Training session. Subjects underwent a ten-week training program following the initial test, during which they viewed 10 sets of 20 film clips similar to those outlined above. During these sessions they were provided with a score sheet identical to the one used in the test situation, and they were asked to predict where the ball landed in the same way.

Following the screening of each shot to the point of contact, accurate results of where the ball actually landed were screened using an overhead projector, and the follow-through of the shot was then shown. Discussion and instruction about factors affecting the outcome was also engaged in, and the framing device on the projector was often used for this purpose.

For motivational purposes, subjects scored their performances and attempted to improve upon them each week. At the end of the ten-week period, subjects were retested using the same tests outlined previously.

Apparatus. All filming was done using a Pathe PR 16 BTL camera (to 80 frames per second) and Kodak 4-x reversal film 4277. All film was projected on an L.W. photo-optical Data Analyzer projector (model 224A). During the court testing, balls were delivered using a J.R.B. all-stroke tennis machine to propel them at constant speed and direction to land in a given area 6 ft. in diameter. Four dozen new, yellow tennis balls were used.

For the court tests, the subjects wore glasses with heavy perspex frames to which an aluminum shutter device was attached. Vision was obscured in every direction except forward, and upwards to an angle of approximately 45°. Mounted on the frame was an electromagnet which was connected by a 100 ft. length of light-duty electrical wire to a pressure switch on the racquet used by the person playing the stroke. The apparatus was powered by two batteries so that it was easily portable. Contact of the racquet with the ball caused the pressure switch to operate, thus releasing the spring-loaded shutter device on the glasses. To dispel doubts about time lag resulting from the circuitry delaying the operation of the shutter to obscure vision at contact, the camera was used to film through the glasses at 64 frames per sec. In one of the five shots taken there was some prolongation of sight. This amounted to the ball traveling a distance of approximately 1 ft. and the racquet head a distance of approximately 2 in. Since all subjects who used the device claimed they could not see anything after contact with the ball was made, it was assumed that if other cases of prolonged exposure occurred they were probably negated by the effects of the blink reflex as the shutter came down.

Earphones were fitted over the head of each subject during the court test and white noise recorded from a sine wave generator was played during each shot to prevent the subject from receiving sound cues as to where the ball landed. Since the test was performed in a gymnasium with a wooden floor, the subjects also stood on a two inch mat to absorb any vibrations emitted by the ball as it bounced. The target area of the court was divided up into squares of 1 m. to facilitate plotting of the position in which the ball landed. The film used for testing and training was spliced from film taken by a professional photographer stationed on the court in the same position as the subjects during the court test, i.e., at the center of the base line. The hitter was positioned at the midpoint of the base line at the other end.

## RESULTS

The subject's score sheets (drawn at a scale of 1 cm.-1 m.) were scored using an X, Y coordinate system on a transparent grid. This was placed over the sheet so that the origin (0,0) was overlying the point where the ball actually landed as recorded by an observer. The subject's prediction was then scored from the coordinates so that an error measure for both lateral and depth prediction was obtained. Negative 'Y' scores indicate a misjudgment as being too long and negative 'X' scores indicate a misjudgment as being to the left of the actual landing point. The scale was chosen so that each scoring unit represented 0.5 m. on a tennis court. For example, if a player received a score of (10,-5), it would mean that he judged that the ball would land 5 m. further to the left and 2.5 m. further away. Direction of error was used only to determine whether there was a consistent tendency for subjects to deviate in a particular direction at this early stage of prediction. Data are summed for each individual over the 10 trials, without taking account of sign, to indicate overall improvement.

Table 1 shows that the subjects improved both in lateral (X) prediction ($p \leq .01$) and depth (Y) prediction ($p \leq .01$) when tested using the film simulation. It also shows that although improvement occurred in prediction on the court, it was not significant.

Table 1

Summing Scores Without Regard to Sign
to Indicate Total Error in Prediction

| Test | Prediction | $x$ "pre" | $x$ "post" | $s^2$ "pre" | $s^2$ "post" | d/f | t |
|---|---|---|---|---|---|---|---|
| Film | lateral (X) | 45.6 | 36.1 | 217.0 | 46.5 | 20 | $2.6^b$ |
| | depth (Y) | 65.1 | 54.4 | 133.3 | 78.1 | 20 | $3.5^a$ |
| Court | lateral (X) | 20.4 | 21.8 | 19.0 | 12.4 | 18 | 1.1 |
| | depth (Y) | 50.5 | 49.7 | 185.5 | 126.3 | 18 | 1.7 |

$^a p \leq .01$

$^b p \leq 05$

When direction of prediction is considered, there is a consistent tendency for subjects to over-estimate on depth in both the film and court conditions (Table 2), as is indicated by the negative means. A significant improvement was shown in this factor ($p \leq .01$) for the court conditions. While a slight improvement occurred in the film condition, it was not significant ($p \leq .05$).

Table 2

Summing Scores According to Sign to
Indicate Direction of Prediction and Improvement

| Test | Prediction | x "pre" | x "post" | $s^2$ "pre" | $s^2$ "post" | d/f | t |
|---|---|---|---|---|---|---|---|
| Film | laterial (X) | -.77 | 0.4 | 31.1 | 19.1 | 20 | 4.9[a] |
| | depth (Y) | -2.7 | -2.7 | 53.4 | 35.9 | 10 | 0.1 |
| Court | lateral (X) | 0.04 | 0.2 | 5.7 | 7.3 | 18 | 0.9 |
| | depth (Y) | -3.4 | -2.6 | 22.7 | 25.9 | 18 | 3.1[a] |

[a] $p \leq .01$
[b] $p \leq .05$

## DISCUSSION

The improvement in prediction evidenced in the film condition compares favorably with the findings of Haskins (1965) and Jones (1974). However, these data indicate that a similar improvement does not appear on the court as a result of the film training despite the structuring of the situation to contain as many identical elements as possible. Improvements on the court test, particularly in lateral prediction, may have been masked by the fact that the subjects performed very accurately on the initial test, thus allowing relatively little chance for improvement.

The prediction of depth was much less accurate than lateral prediction and seems to rely much more upon information processed about the flight of the ball after it has left the racquet. This is supported by the findings of Whiting et al. (1973, 1974a, 1974b) and Alderson et al. (1974). It is evidenced in this study by the consistently higher means obtained in both the film and court tests for the depth measurements. However, it would appear from the film results, which show a significant improvement in depth perception, that there is still a large component of this prediction which is made prior to contact.

The fact that subjects consistently over-estimated depth in both the film and court conditions may be related to a movement strategy rather than to a consistent error in prediction. In making what is essentially a gross prediction prior to the opponent's contact with the ball, the subjects would realize that it is much easier to move forward than backward if the prediction is in error, and that in terms of the mechanics of the stroke this is the most desirable direction of movement anyway; hence the general tendency toward any over-estimation.

All subjects in this experiment were very good tennis players relative to their age. It may be, therefore, that if the project was repeated using beginners for subjects an improvement would be seen on the court test. However, because incidental learning of these perceptual skills obviously occurs during the game and real practice situation, the question would remain as to whether time is not better spent in the real skill situation than in the artificial one.

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# AGGRESSIVENESS IN TENNIS:
# ASSESSMENT AND RELATED FACTORS

by

P. Graham Hatcher
Department of Physical Education
Carson-Newman College
Jefferson City, TN

Richard L. Miller
Department of Psychology
Western Kentucky University
Bowling Green, KY

## Abstract

Due to the nature of the game, the aggressive tendencies of the tennis player are not easy to determine. Court aggression (play) and psychological aggression are two areas that have received little attention but represent potential importance to the player and coach. The Court Aggression Rating Scale (CARS), developed and validated by the authors, has been employed in two investigations concerning relationships existing between court aggression, psychological aggression, and skill in male and female intercollegiate tennis players. In each study the subjects completed a personality questionnaire and were rated by experts using the CARS. In one study the subjects performed under varying conditions of low and high chances of success and were further assessed for skill levels in forehand, backhand, and serve. Results suggested that psychological aggression tends to hinder performance and that success in tennis may be positively related to aggressive play. Men displayed higher court aggression than did women; however, women showed evidence of higher psychological aggression. The data suggest a strong likelihood that aggressiveness in one aspect of play would carry over into other aspects as well, except for the serve. The results also identified several factors related to skill level in tennis.

Due to the nature of tennis in comparison to other sports such as football and ice hockey, the aggressiveness and tendencies toward aggression of the tennis player are not easy to determine. While aggression is going to be inherent in any competitive setting (and tennis is certainly no exception), it can often be difficult to determine aggressive behavior and it is not an easy task for the tennis teacher/coach to encourage or discourage selected behaviors.

Cratty (1973) has categorized tennis as a sport of indirect aggression; in other words, the aggression from one's opponent is felt physically but indirectly. By propelling objects (missiles) at one another, the object (missiles), rather than the players, accomplishes the hitting and receives the hitting.

Two types of aggression will be discussed here--court aggression and psychological aggression. Court aggression pertains to court behavior relating to offensive and attacking tactics manifested through the playing styles of tennis players engaged in competition. Television commentators, sports reporters, and even casual observers of the game have noted on numerous occasions the on-court aggressiveness of tennis players. (Reactive aggression is rarely, if ever, witnessed by virtue of its control by the rules of the game. Instances of verbal aggression have been rather prevalent in intercollegiate and professional competition in recent years.) Lorge (1979) uses the following descriptive terms in just one paragraph of a discussion of the play of an inspired Jimmy Connors against Bjorn Borg: "jumped," "ripping," "slashing bloodthirsty volleys," "sliced and pounded," "slashed," "hurled outright winners," "exploded like Molotov cocktails in the night."

Several articles have recently appeared in World Tennis concerning aggression as an important component in successful singles and doubles play.

But court agressions has been considered valuable since the early days of tennis--e.g., Spencer Gore's introduction of the volley (1870s); perfection of the volley and introduction of the overhead smash by Ernest and William Renshaw (1880s); Oliver Campbell's introduction of hitting the ball on the rise for an approach shot (1890s); and H. F. Lawford's introduction of topspin drives (1890s). In fact, court aggression had to be on the mind of Dwight Davis in the late 1880s when he conjectured that "a better, more aggressive game of tennis" (Grimsley 1975) was played in the U.S. rather than in England. Stroke development and strategies which have evolved through the years have aided in determining the extent of aggressiveness on the part of the players.

Psychological aggression, as indicated by the personality inventories employed, relates to an individual's predisposition towards release of aggression, willingness to make use of force to accomplish the task at hand, argumentativeness, and tendency to make a retaliative attempt (i.e., to "get even" with people). High psychological aggression scores would tend to imply a rather substantial amount of personal conflict. While court aggression and psychological aggression have received some attention, they do represent areas of potential importance for the player, teacher, and coach.

One investigation (Hatcher 1979) concerning an examination of the interrelationships existing among skill, court aggression, and psychological aggression was conducted by the first author. Twenty-four male and female intercollegiate tennis players served as subjects. Briefly, methodology consisted of the athletes completing a personality questionnaire in order to determine their level of psychological aggression. The players completed a tennis skills test which yielded separate skill scores for the forehand, backhand,

and serve, in addition to a composite skill score. The athletes were filmed during competitive play against a common opponent under two different situations--high and low chances of success, i.e., opponents they should beat or should lose to, based on skill tests results. The films of the players were observed by a panel of tennis experts who evaluated their play according to the guidelines for assessing court aggression as indicated by the Court Aggression Rating Scale (CARS) developed by Hatcher and Miller (see Appendix).

It should be mentioned here that the CARS is a valid and reliable instrument for assessing court aggression. In fact, it happens to be the only known, available guide for the teacher/coach wishing to employ an objective method of evaluation of his student's/player's aggressiveness on the court. The CARS identifies and isolates behaviors expressing aggressiveness in the following major categories of tennis play: serve, return, forehand, backhand, volley and half-volley, and lob, along with a miscellaneous (catch-all) category for additional strokes and situations not previously covered.

As a result of a variety of statistical analyses of the data collected from the studies, a number of interesting conclusions can be posited which have implications for those teaching and coaching tennis.

1. Psychological aggression levels that are above average appear to be a strong hindrance to skill acquisition and improvement, as well as to court aggression. As psychological aggression levels increase, skill and ultimately performance levels tend to decrease. This should not appear surprising to knowledgeable students of the game--skill execution requires mental control and rational thinking and planning; high degrees of psychological aggression can block and inhibit these processes. As mentioned previously, high psychological aggression scores imply conflict of an intrapersonal nature. As an

individual's skill level increases (and consequently his performance improves), psychological aggression needs to be, and is, better controlled. Those players with high levels of court aggression display an ability to control psychological aggression. Court aggression, then, is not a "letting out" at one's opponent, but rather a tactical as opposed to an emotional aggression.

2. The fact that men prove to be more aggressive on the court could possibly indicate that there may be some differences between the sexes in the expression of court aggression. Since psychological aggression scores are higher for females (which has been supported by additional research), and since males score higher on the skill test, this conclusion is not totally surprising.

3. With respect to court aggression, results appear to strongly suggest that if a player is aggressive in one aspect of play, then he/she will be aggressive in other aspects as well. Aggressiveness on the court comes from having played a great deal of tennis; from the secure and comfortable feeling that comes from knowing one has an appropriate, aggressive style of play; and from confidence in one's own skill level. It follows, then, that court aggression is, in general terms, representative of a person's skill and self-confidence levels.

4. Well-developed forehand skills in players tend to imply a strong tendency to express court aggression, while a weaker relationship appears to be characteristic of the backhand; therefore, the backhand stroke tends to play a more conservative role (with respect to court aggression). Due to the lack of a significant relationship between service skill and court aggression, we can assume that the better players favor a more consistent serve rather than a highly aggressive serve. Once the ball is in play, court

aggression can be displayed in the groundstrokes.

5. Results of one study indicate that points won are played more aggressively than points lost. Due to other factors, we cannot accurately predict that playing aggressively will result in successful performance, just as successful performance does not always manifest itself in high court aggression. Court aggression obviously has to be controlled, and perhaps the main point of consideration is when control of the point is established. It appears to follow that being in control of the point would provide the optimum setting for the player to express court aggression leading to winning the point.

The results of these studies have benefit for players, teachers, and coaches of tennis. Players of all levels now can be made aware that relationships do exist between court aggression and various skills. There appears to be strong support in favor of developing aggressiveness in one's style of play.

The CARS can enable the coach to take a more objective look at his players with respect to court aggression, with the results being helpful in encouraging players toward a style of play befitting their ability. Procedures used in the study can also be of help in providing insight into the analysis of play and shot selection.

As behavior modification techniques are applied to teaching tennis, specific programs can eventually be developed to target selected aspects (strokes) of play to be improved. The potential exists for self-instructional settings as well as the more traditional teacher-student setting. While court aggression in tennis players may not receive as much attention as a player's won-loss record, it does exist in several forms and should be considered an important factor of an individual's play.

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## COURT AGGRESSION RATING SCALE

1. NON-AGGRESSIVE = passive, defense-oriented; relaxed and comfortable on baseline; when drawn to net, returns back
2.
3. SELDOM AGGRESSIVE = occasionally hits forcing shots; in tense situations more relaxed on baseline, tends to lob rather than hit passing shots
4.
5. MODERATELY AGGRESSIVE = combines offensive and defensive styles into effective game plan; alternates adequately between the two
6.
7. FREQUENTLY AGGRESSIVE = in tense situations more relaxed up at net; tends to hit passing shots rather than lobs; frequently hits forcing shots
8.
9. HIGHLY AGGRESSIVE = dominant, offense-oriented; rushes net at every available opportunity; hits attacking and forcing shots

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|  | HIGHLY AGGRESSIVE | MODERATELY AGGRESSIVE | NON-AGGRESSIVE |
|---|---|---|---|
| SERVE | hard, nearly flat, hit to corners and opponent's weakness, does not let up on 2nd serve, hit deep into service court, follows serve to net (both 1st and 2nd) | hard 1st, spin on 2nd, will probably attack net if 1st serve is forcing, rarely attacks on 2nd serve unless it is hit out | spin on both serves, little placement, used to just get ball in play, never follows it to net, serves are not necessarily deep and never overpowering |
| SERVICE RETURN | returns generally are hard and forcing, may even chip 2nd serve and attack net, if opponent attacks net may attempt passing shot or hit directly at feet | mixes up forcing returns when able, and lobs returns when forced, tends to hit at feet of attacker rather than pass, hits deep (relatively near center) if server stays back | returns just get ball back in play, little placement on shots, would tend to lob returns if server attacks, stays back |
| FOREHAND | topspin, low, hard, forcing attacking shots, alternates often from corner to corner or may specifically attack opponent's weakness, nearly always used in passing opportunities | may use topspin, backspin, or flat shots when opportunity arises, almost always used in passing opportunities, often hit to opponent's weakness | generally high, softer than an aggressive FH, ball is kept in play, more defense-oriented, may use underspin or high arching shots to control tempo, rarely used to pass opponent |

| | HIGHLY AGGRESSIVE | MODERATELY AGGRESSIVE | NON-AGGRESSIVE |
|---|---|---|---|
| BACKHAND | topspin, with an occasional backspin shot, low, hard, and forcing, rarely in middle of court, often used in passing opportunities | generally underspin with an occasional topspin, seldom used in passing situations, hit to opponent's weakness | backspin for control rather than power, ball may tend to float, rarely if ever used to pass an attacking opponent |
| LOB | generally topspin, used offensively when opponent has closed net, usually hit when put in forced position (otherwise would hit passing shot) | mostly backspin with an occasional topspin, used in both offensive and defensive situations, hit relatively deep, may be used to change pace or set tempo of match | backspin as a rule, used defensively to allow time to get back into point, used in lieu of passing shots and attempted deep |
| VOLLEY AND HALF VOLLEY | used as an offensive weapon, comes to net at every available opportunity, attempts to win point on 1st volley, shots are hard and attempted forceful, closes net after each volley, HV used when attacking net, racket comes over ball (topspin) | used after good 1st serve and approach shot, rarely follows 2nd serve, does not necessarily try to win point on 1st volley, HV is generally used to get ball back in play | uses volley only when drawn to net, uncomfortable with shot and just tries to get ball back, hits shots safely within court, HV is seldom used (generally near baseline used with backspin, might favor HV over volley) |

| | HIGHLY AGGRESSIVE | MODERATELY AGGRESSIVE | NON-AGGRESSIVE |
|---|---|---|---|
| MISCELLANEOUS | attempts to force action, hits ball on rise, attacking or offensive intent is the important criterion, weight should be forward, "grunt" may draw opponent up to allow for potential pass | the degree of aggressive intent is the important criterion, weight should be generally evenly distributed after a shot, may hit angle shots after pulling opponent in and then hit a passing shot | passive or defense-oriented intent is the important criterion, weight should be slightly back, degree of defensiveness is to be considered |

# TEMPORAL LIMITATIONS IN TENNIS

by

L. Russell Morris
Motor Behavior Laboratory
Institute for Child Behavior and Development
University of Illinois at Urbana-Champaign
Urbana, IL 61801

## Abstract

In tennis, when a ball is hit by an opponent a player must react to the shot. A correct movement entails a decision restricted by time. The purpose of this study is to examine the temporal limitations of the tennis player in order to better channel the efforts of the coach/teacher in the teaching of tennis. The temporal limitations are derived from measurements of ball velocity from highly skilled tennis players during actual match play. These results are compared with an additional twelve highly skilled players who were tested in laboratory conditions for simple reaction time and choice movement time. Results suggest that, due to the temporal limitations placed on a tennis player by the high velocity of the ball over the short distances of a tennis court, reaction time alone does not account for highly skilled players' ability to respond correctly to the opponent shots. The hypothesis is supported by the laboratory test's results, which are slower than the times required to react to the hit of the ball. The results are explained by the players' ability to perceive relevant cues and anticipate the spatial and temporal characteristics of the coming hit.

Temporal limitations in tennis are those factors which limit a player's performance due to time constraints. Two situations so constrained in the sport are: (1) the ability to react to an opponent's shot, called "response time"; and (2) the critical timing of one's own stroke, which has been called "transit reaction time" or "coincidence timing." This presentation will be limited to the first type.

Response time, or the period of time from the occurrence of a stimulus until the desired goal is achieved, has been studied by experimental psychologists for many years. It is fractionated as follows: (1) reaction time, which is probably the most easily recognized component, is the period of time from stimulus initiation to the beginning of the person's overt response movement; and (2) movement time, which is the period of time from overt response movement to goal achievements. Thus, reaction time plus movement time equals response time.

Reaction time can also be broken down into premotor and motor times; the latter being the period during which there is muscular activity in the reacting limb during the reaction time phase (that is, before movement occurs). Actually, this is the period during which the inertia of the limb is overcome, once the muscles are activated, and in most cases accounts for approximately 20-25% of the total reaction time. Of greater interest to the researcher, however, is the other 75-80%, which is termed "premotor time." This is the period of time from the stimulus to the beginning of muscular activity. Premotor time can be thought of as containing three elements. The first stage, a perceptual input stage which occurs through the MODES of vision, audition, or proprioception, is the length of time required to perceive a stimulus. It is dependent on the neural circuitry of the organ's afferent tracts to the perceptual brain center, e.g., audition is faster, on the average, than vision (about 140 msec. compared to 180 msec.). The second stage is decision making: once a stimulus is perceived, a decision must be made as to the correct reponse. In the laboratory setting this is often a simple button press or arm movement; in tennis, however, it might entail a complex decision as to direction of movement, type of movement, and body orientation, thereby encompassing many muscle groups. The third and final stage is the output stage where the efferent command is sent to elicit the proper muscular response. As in the input stage, the temporal aspects are fairly stable and are a function of "wiring" of the neurological system. The biggest temporal variation during reaction time, and most likely the only one which can be reduced to any extent, is the decision-making process.

While simple reaction time (RT) in a laboratory setting is often measured and sometimes used as baseline data, Whiting (1969: 18) notes that it is "unlikely that simple reaction time as measured in the laboratory is analogous to any situation in ball games." Such would be the case in tennis. However, choice reaction time (CRT) may be relevant. In this case, the subject or player must choose between several possible stimuli and responses in the laboratory setting. The stimuli and responses are consistently mapped (i.e., the rules determining which response is correct for a certain stimulus are known and stable) and the results can be analyzed without confusion. The SR mapping in an ecological setting such as a tennis match is unfortunately not as well defined and is therefore more difficult to analyze.

Choice reaction time tends to be considerably longer than simple RT, and it is, as Hick (1952) and Hymann (1953) discovered, a function of the number of possible alternatives: it increases in direct proportion to both the number of variations in time and space which are available to a player and the number of ways in which a ball can be returned. Thus, it is evident that the major factor in reducing CRT is during the decision-making stage of premotor time.

During play, a situation may arise in which the initial stimulus is replaced by a closely followed second stimulus--for example, mis-hit shots or balls that strike the net cord. In these cases, it has been demonstrated that the reaction to the second stimulus will take approximately 100 msec. longer than if the first stimulus had not occurred. This phenomenon is known as the "psychological refactory period" (Smith 1967).

Movement time is also a limiting factor for many players. As Vic Braden (1980: personal communication) states, "the shorter the stroke the more efficient it is and the less time it takes from reaction to point of contact." Many beginners, in learning to serve, for example, feel as if they do not have enough time to go through the entire service motion after the ball is tossed into the air; this is usually due to excess motion. In certain situations during a tennis match, the combination of ball speed and distance traveled requires a rapid response by a player under a time constraint, e.g., the response of a net player to a passing shot. It is not uncommon to hear coaches commenting on a player's "reflexes." This refers to the player's ability to respond quickly to shots hit at close range by an opponent. More than one youngster has been eliminated from the sport because of "slow reflexes."

To evaluate the relationship between actual reaction times and the possible temporal constraints imposed in tennis, psychophysiological data on highly skilled women tennis players were collected. In the first experiment, simple visual reaction times and two choice visual response times of 12 female tennis players were tested under laboratory conditions. The subjects were varsity members of tennis teams at both the University of Southern California and the University of California at Los Angeles. These teams were ranked first and third, respectively, in the United States, and about half of the subjects were nationally or sectionally ranked. Therefore, all subjects were considered to be highly skilled.

The method of testing reactions time consisted of the subject pressing a button with the index finger of her dominant hand in response to a single light stimulus. Results were measured in milliseconds by a Decan Digital Timer. In the two-choice response condition, subjects stood in a ready position with racquet in hand. A pressure pad was placed adjacent to the outside of each foot and was connected to the timer. Directly in front of the subject, at a distance of 45 ft., two white lights were positioned 3 ft. above the ground and 1.5 ft. apart. These positions were chosen to approximate actual distances in game situations when a net player must respond to a passing shot. The task involved the subject raising the racquet and stepping in the correct direction as soon as possible after the stimulus light came on. Time was again recorded in milliseconds from stimulus onset until the subject's foot hit the pressure pad. In the simple RT condition, 60 trials were collected; in the two-choice condition, 40 trials were administered with each side received an equal number presented randomly.

## RESULTS

Results for the simple RT condition ranged from 177 to 250 msec., with the mean for the group being 210 msec. (Table 1). This reactions time is slightly slower than the 180 to 200 msec. often quoted in the literature. The two-choice response condition times ranged from 501 to 769 msec., with a mean of 587 msec. There was no difference as to whether the subject moved to the right or left (means of 584 msec. to 591 msec.). Unfortunately, normative data were unavailable for comparison.

Table 1

Simple RT and Choice Movement Times of Subjects

| Subject | Simple Reaction Time | Choice Movement Time (To Right) | (To Left) | Combined |
|---|---|---|---|---|
| 1 | 210 | 526 | 495 | 510 |
| 2 | 210 | 597 | 538 | 567 |
| 3 | 220 | 729 | 699 | 714 |
| 4 | 230 | 568 | 500 | 534 |
| 5 | 204 | 592 | 567 | 580 |
| 6 | 196 | 557 | 548 | 552 |
| 7 | 199 | 613 | 630 | 622 |
| 8 | 218 | 559 | 552 | 555 |
| 9 | 216 | 776 | 762 | 769 |
| 10 | 250 | 597 | 556 | 576 |
| 11 | 222 | 482 | 520 | 501 |
| 12 | 180 | 538 | 600 | 569 |
|  | 210 | 584 | 591 | 587 |

Figure 1 shows the time it takes a tennis ball (hit with an average velocity) to travel 45 ft.--roughly the distance from the base line to the position of a net player. It is not difficult to observe that a tennis player must at times anticipate an opponent's shot and begin movement prior to hitting the ball.

## CONCLUSIONS

In order for these highly skilled tennis players to compete successfully in tournament tennis, they must be able to anticipate in space and time the characteristics of their opponents' shots (Jones 1978). As Vic Braden has stated many times, the professional player occasionally anticipates incorrectly and responds to a stimulus by moving in the wrong direction. The advanced player moves with the hit, but the beginner rarely does. The novice player will wait until the ball bounces on his/her side of the court, thereby handicapping themselves by limiting response time to a stimulus which may be moving more slowly but which also does not have to travel more than a few feet after the bounce before it must be returned.

Possible remedies for the problems created by these temporal limitations are as follows.

1. Make sure your students are reacting to the correct stimulus--moving with the hit of the ball; they should not be afraid to be wrong.

2. Through a cognitive understanding of the basic mechanics of tennis, instruct your students to observe the relevant cues of an opponent--i.e., stance, direction of swing, direction of racquet face, and point of contact. While these points may seem obvious, there are players who don't even realize that their opponent is left-handed.

3. Develop a strategy--in similar situations, what type of shot did the opponent hit, especially under pressure?

3. Are there any environmental factors influencing an opponent's decision to hit--i.e., wind, sun, your position on the court?

The ability of a player to use these four factors should enhance his/her ability to anticipate an opponent's shot in order to respond more quickly and more efficiently.

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# GENERAL RESEARCH

# IN

# THE RACQUET SPORTS

# APPLICATION OF TENNIS RESEARCH

by

Stanley Plagenhoef, Ph.D.
Boyden Gymnasium
University of Massachusetts
Amherst, MA 01002

## Abstract

The purpose of this paper is to present an overview of contemporary tennis research and its application to the practitioner. Two basic areas of research are discussed: (1) ball velocity relative to racquet characteristics, and (2) time requirements of good athletes to react to and play the ball. It is concluded that industrial innovations are responsible for two major factors affecting the game-court surface and racquet characteristic changes. It is shown that play has not changed and research has actually offered little to aid the game of tennis.

The practical application of completed research in tennis requires an analysis of changes that took place in the game as a result of that research. Changes can take place in equipment, in the court surface, or in the individual. Individual changes can further be divided into the mechanics of the strokes and physical and mental aspects of the game.

This broad spectrum is narrowed down to two research areas for this presentation: (1) ball velocity relative to racquet characteristics, and (2) time requirements of good athletes to react to and play the ball. General statements relative to all areas, however, are enlightening when attempting to assess the impact of research on the game.

Motion pictures taken from 1952 to 1979 at Forest Hills and Longwood (edited and presented at this symposium) show that the change in the court surface is the major factor influencing the game. Players adapt their grips and strokes, and certain physical and mental characteristics are more successful according to the surface. When the major tournaments were no longer played on grass, and more time became available to hit a ground stroke, strokes changed as well as grips to adapt to the higher ball bounces. Everyone easily identifies the advantage of a power hitter on a fast court, as well as the physical and mental stamina required to sustain long points on slow courts. The chemists and aeronautical engineers had an impact on the change in the racquets and are probably most responsible for the public's switch to lighter racquets in recent years. The first research topic deals with this racquet change.

## RESEARCH PROJECT #1

Slow-motion pictures (64 f/s to 200 f/s) were used to analyze ball velocities. This was presented in Fundamentals of Tennis (Plagenhoef 1970), and much of that book is cited in the AAHPER booklet "What Research Tells the Coach About Tennis" (Cooper 1974). One of the facts presented was that the ball velocity after impact did not correlate linearly with racquet head velocity, thus making the grip during impact an important variable. This point was also investigated by Baker and Putnam (1979). They hit clamped racquets and free-standing racquets from a ball machine at a distance of 25 ft. with a ball velocity of about 85 ft./sec. The balls were hit dead center on the strings, and no change in ball velocity after impact was found under the two conditions. Thus, grip strength was declared an unimportant factor. Baker and Putnam found that wood racquets produced a higher velocity than graphite or fiberglass frames.

The research of Elliott, Blanksly, and Ellis (1980) and of Plagenhoef (1980), shows that it is the off-center hit that results in varying velocities and thus makes grip strength during impact very important. A firm grip at impact will, in fact, result in higher ball velocities if a ball is hit off center. The resulting torque created by a ball hit off center on the transverse axis must be countered by the squeeze of the hand. The larger the grip, the easier to counter the twist due to impact. The fact that wood frames produce greater velocities is probably a function of head weight, not material, as Plagenhoef (1980) finds head weight to be an important factor in producing ball velocity. Tennis research, therefore, is not responsible for the industry's change to lighter frames and smaller grips, and no one is heeding the research results that racquets should be more like they were years ago, i.e.. heavier and with larger grips. In this case, the application of research is needed to keep other research from being misleading and to counter misinterpretations that might be used by tennis teachers.

## RESEARCH PROJECT #2

The tennis coach is constantly trying to get players in a "ready position" soon enough to react as quickly as possible to the ball coming off the opponent's racquet. This not only requires that the racquet is ready in front of the body, but that the player times the foot movement pattern (split legs) to coincide with the ball being struck. How does one know if the split is being timed at the proper moment? Molstad (1974) did a research study using a ball-throwing machine to (1) catch a ball, (2) intercept it (contact), and (3) deflect it with a paddle. The subject was 25 ft. away and the ball velocity was 50 ft./sec. The time to the person was 0.5 sec. Performed indoors, the lights were turned off at time intervals of 0.4, 0.3, 0.2, and 0.1 sec. after the ball left the machine. Subjects familiar with those sports, like tennis, having a moving ball (called an "open skill") and those who played golf or bowled (called "closed skills") were used. In addition, the subject had a finger on a switch to measure reaction time to the visual stimulus of the ball coming. It took 0.18 sec. to lift the finger prior to movement toward the ball. The past skill was insignificant and the percentage of success got lower as the viewing time decreased.

This has implications for determining the length of time an individual must track the ball, and when a player must go into the "leg split ready position" to move toward the oncoming ball. It was necessary, however, to do a similar project under conditions move relevant to tennis. Conditions were varied so the body could not pre-program the movement to a specific spot, a flaw in the Molstad design. Machine to subject distance was placed at 36 ft. and 40 ft. using two ball velocities of 47 ft./sec. and 55 ft./sec. at each distance. A ball machine was used that put topspin on the balls, making it more difficult to track when the lights went out. A timer was wired to a switch that was hit as the ball left the machine. The subjects volleyed the ball on the forehand side only and were not aware of the moment the ball was being fed into the machine. The results are presented in Table 1.

Table 1
(n=12)

| Subject Distance | Ball Velocity | Time Ball Viewed [a] | % Distance Ball Viewed | | Balls Hit | |
|---|---|---|---|---|---|---|
| | | | | Good | Poor | Missed |
| 36 ft. | 47 ft./sec. | .6 s | 78 | 9 | 1 | 0 |
| | | .5 | 65 | 8 | 2 | 0 |
| | | .4 | 52 | 4 | 4 | 2 |
| | | .35 | 46 | 1 | 5 | 4 |
| [a] *Total time = .766 sec. | | | | | | |
| 36 ft. | 55 ft./sec. | .6 | 91 | 9 | 1 | 0 |
| | | .5 | 76 | 6 | 4 | 0 |
| | | .4 | 61 | 2 | 6 | 2 |
| | | .35 | 54 | 0 | 6 | 4 |
| [a] *Total time = .654 sec. | | | | | | |
| 40 ft. | 47 ft./sec. | .6 | 71 | 9 | 1 | 0 |
| | | .5 | 59 | 8 | 2 | 0 |
| | | .4 | 47 | 5 | 4 | 1 |
| | | .35 | 41 | 2 | 7 | 1 |
| [a] *Total time = .851 sec. | | | | | | |
| 40 ft. | 55 ft./sec. | .6 | 83 | 9 | 1 | 0 |
| | | .5 | 69 | 7 | 3 | 0 |
| | | .4 | 55 | 4 | 5 | 1 |
| | | .35 | 48 | 2 | 5 | 3 |

[a] Total time = .727 sec.

The success rate was high if the ball was seen 91% of the distance at 55 ft./sec. and 78% of the distance at 47 ft./sec. when the ball traveled 36 ft. Success fell off rapidly to an unacceptable percentage for playing good tennis. The results show that subjects performed well when viewing time was 0.6 sec., but they did poorly as the time got below 0.5 sec. A served ball takes only 0.42 sec. to go from the bounce to the receiver's racquet on a fast surface, so it is necessary to watch the ball as long as possible for best performance.

A "lights out" research project added no new information except to reinforce the need for watching the ball. The results, however, have some practical value as far as getting the body "ready" at the proper time. Molstad (1974) showed that reaction time to the initial ball flight was 0.18 sec., but it is still necessary to determine the time needed by an athlete to be successful without interrupting the viewing of the ball. Therefore, another project, was undertaken to determine what time element was needed without moving the feet while moving the hand only a short distance. Using slow-motion pictures taken during competition, measurements were obtained on athletes in tennis, badminton, squash, hockey, baseball, soccer, and lacrosse to determine the time necessary to make a volley or for a goalie to make a stop. This time factor was 0.37 sec. to be playable (based on performances of world class athletes). A tennis volley exchange was possible if the time from racquet impact on one side of the net to racquet impact on the other side was at least 0.37 sec; if the time was shorter than this, the ball was missed. Likewise, a badminton smash measured from racquet to racquet, or a quick exchange in squash, required 0.37 sec. to be playable. Also goalies in all sports needed at least that amount of time to stop a goal if they did not have to change position to get to the ball or puck. The exception occurred when a goalie "read" body motions and guessed at the direction of the shot. The "reading" of opponent body motions is a very important factor, and many tennis players go to a pre-determined spot on the court when approaching the net for a volley, rather than getting set to go in any direction. A baseball batter is in a different situation since it is necessary to start the motion of the front foot with ball release, simultaneously "reading" the ball flight, as a fast ball takes about 0.37 sec. to get from the pitcher's hand to the bat.

Thus, about half the time in tennis is needed to "read" ball flight and the other half to execute a slight hand movement. Additional time is needed to move for a ball several feet away, but the timing of the "leg split" to be ready to move should be about one-third second after the opponent's ball contact. This can be demonstrated by taking motion pictures from behind the court and measuring the time from opponent's ball impact to the leg split. If the film rate is 100 frames per second, the feet should be spread and the weight coming down about 30 frames after impact. If a person is still stepping or not going into the split at this time, they will not be able to cover as much court sideways. The movies shown indicate that people playing well do in fact time the split at this time interval; and when they are late, they are more likely to get passed. Good athletes have been performing according to their innate physical ability and research has simply gotten better at telling everyone how well they perform. The movies presented show that people have not changed, the velocity at which the ball is hit during play has not changed, and that research has offered little or nothing to aid the game.

## SUMMARY

1. Industrial innovations were responsible for two of the major factors affecting the play of tennis:
    a. the court surface (cement, roughened asphalt, compositions, and synthetics); and
    b. racquet characteristic changes.
2. Ball velocities during play have not changed over many years, except to adapt to the court conditions.

3. Athletes' physical abilities to play well have not changed.

4. Research application is used to:

   a. clarify other research; and
   b. present factual data for better instruction. Good players often tell it differently than the way they do it.

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# RESEARCH AND ITS ROLE IN TEACHING/COACHING RACQUET SPORTS: A SYNTHESIS

by

Jack L. Groppel, Ph.D.
Head Tennis Coach and
Assistant Professor of Physical Education
University of Illinois at Urbana-Champaign
235H Armory
Champaign, IL 61820

It is evident to most people who enjoy physical activity that the racquet sports have had a marked effect on society over the past few years. Millions of men, women, and children have thronged to the court for exercise, fitness improvement, competition, general recreation and a multitude of other reasons.

With the sudden increase in enthusiasm for the racquet sports, skilled instructors are necessary to teach correct movement patterns. This instruction can range from a very concise, mechanical approach to teaching, to a psychological approach, wherein mechanics are not even discussed. In fact it is possible that during a discussion among ten teaching pros of a certain racquet sport, one might hear ten different instructional methods for one stroking movement. This places the novice, intermediate, and (often) the skilled performer in a precarious situation, attempting to determine which instructional strategy to follow.

There has never existed any consistent means by which this research could be collected, interpreted for the practitioner, and disseminated to players and coaches. For this reason, the University of Illinois College of Applied Life Studies and Department of Physical Education recently hosted this second

"International Symposium on the Effective Teaching of the Racquet Sports."

These symposium participants consisted of about 40 percent sport scientists and 60 percent coaches and/or players. The focus was to provide for interaction between these two previously unacquainted groups. Four racquet sports were represented: badminton, racquetball, tennis, and squash. Some of the most noted authorities were present to give instructional clinics. For example, Vic Braden discussed recent innovations in tennis instruction uncovered only through practical research. Such topics as how spin is produced on the ball, how the serve is actually performed, or how one moves from side to side most efficiently were only a few of the research-oriented presentations. Similar presentations were heard from Dave Fish (squash), David Waddell (badminton) and Chuck Sheftel (racquetball).

In terms of research papers, some biomechanical and physiological studies were discussed concerning the prominence of tennis elbow in badminton players, the ground reaction forces involved in hitting overhead power strokes in badminton, and mechanical comparisons between male and female racquetball players. Motor learning and instructional strategy sessions were included in addition to several studies on psychomotor behavior when participating in the racquet sports. Sports medicine presentations were given by Dr. Robert Nirschl (tennis elbow prevention and treatment) and Dr. Barry Unger (cardiovascular involvement in tennis). These leaders in their respective medical fields imparted a great deal of information that we, as teachers, can find quite valuable if used effectively.

Effective use of the presented information is the key in the dilemma of "bridging the gap" between the researcher and the practitioner. If you were a participant in this symposium and are involved in teaching any of the racquet sports, you must be prepared to extract what information you can from the abundance of data presented. Many teachers/coaches, I feel, are in the business of receiving only data that is self-evident and do not really try to "search" for the answers. In essence, we (and I include myself, as a tennis teacher and coach) cannot expect to be spoon-fed the vast data that were presented. We must use initiative, examine the presentations, and extract what we need.

In contrast, researchers must examine their questions more critically. Are we, as scientists (again, I include myself since I conduct biomechanical research in tennis), actually accomplishing our goals of supplying the teacher/coach with useable information? More often than not, we study problems that are impractical (the coach already knows the answer) or too sophisticated (the data do not mean anything to the practitioner). We need to scrutinize ourselves more directly in deciding: (1) What is a particular study's purpose? (2) What am I trying to achieve? (3) Who will benefit from this research and how will they be able to use it?

Now, the question must be asked "Is research on the racquet sports worthwhile?" The answer could be "yes" if we are more critical of ourselves than of others. It must be realized that principles of playing are quite different from principles of teaching. Once this is understood, research will begin making a significant contribution to the racquet sports.

In organizing a symposium of this nature, it is difficult to avoid controversy. One speaker presents a topic and the rationale behind it, then another speaker discusses the same idea in a totally different fashion and includes that idea's rationale. It must be understood that this will be the case any time leading individuals in their respective field are brought together to discuss their preferred methods of teaching/coaching. The controversy is said to be confusing, but it definitely should not be confusing. This only serves to amplify the fact that "there is no perfect way to perform or teach." Our job, then, is to interact with the various speakers and extract the information we need and use it. The interaction that took place during this symposium was similar to that which occurred at last year's symposium. The results from the "National Symposium on the Racquet Sports" were so overwhelming that this year's meeting was termed an "international" affair. The response to this year's symposium was so good that it will continue at the international level. Also, a steering committee has been organized to assist in drawing together individuals of common interest throughout the world. In this manner alone can we, as involved racquet sport enthusiasts, begin to grasp and appreciate the vast amount of knowledge available to us.